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THE "FONTAINE" LOCOMOTIVE.

To the Editor of the Scientific American:

In compliance with your special request, I have much pleasure in furnishing the following data and remarks relative to the locomotive engine "Fontaine." A very general description of the leading particulars has been given previously, but as many of your readers may not have seen those particulars, it will not be out of place here to reproduce some of them:

Diameter of cylinders	16 in.
Stroke of pistons	24 "
Diameter of driving wheels	72 "
" " friction "	56 "
" " rolling "	70 "
Total wheel base	21 ft. 5 "
Total weight of engine in working order	84,000 lb.
" " on drivers	84,000 "
Diameter of barrel of boiler	48 in.
Dimensions of fire grate	62 in. x 33½ in.
Number of tubes	140
Outside diameter of tubes	2 in.
Length of tubes	11 ft.
Square feet of grate surface	14½
" " " heating surface in fire-box	100
" " " " " " tubes	806
Total heating surface	906 sq. ft.

For several months the engine has been running in general passenger service on the Canada Southern Railway, and during that time has done some good work. The boiler and machinery differ in construction very little from those of the ordinary kind, except that the driving-wheels are elevated so that their axle is just above the top of the boiler, and the cylinders and motion work are at an inclination of 17½ degrees to correspond. In a vertical line, and immediately between the drivers and the rails, are auxiliary wheels of a double tread construction, combining friction and rolling wheels in one. Both driving and friction wheels have plain cylindrically turned steel tires, but the rolling wheels have the ordinary flanged tires for running upon the rails. The spread or gauge of driving and friction wheels is alike, the inner faces of the tires being just wide enough apart to clear the outside of the rolling wheels.

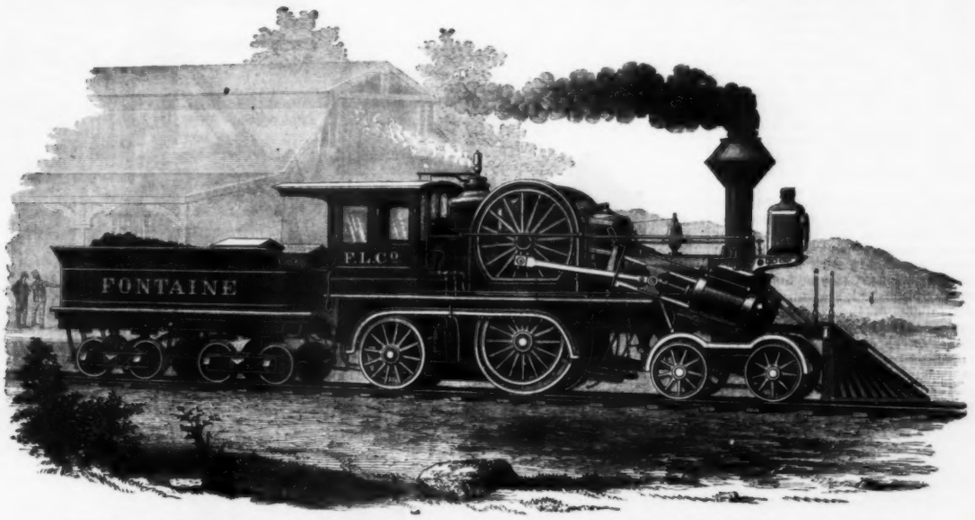
The propelling power of the rolling wheels is entirely due to the frictional contact and revolving force communicated to the friction wheels by the drivers, and is proportionate to the weight and force with which the frictional surfaces are brought together and made to revolve. In order to insure the efficiency of the frictional contact and prevent the wheels slipping over each other, a small steam cylinder communicating with the boiler is fixed on each side framing, to which a system of levers and connections is so devised that by opening the communication between the boiler and small cylinders, the upper and lower wheels are brought together with a force considerably above the normal weight effected by mere gravitation of the drivers, so as to include the weight of the lower wheels in the adhesive power of the engine. This frictional device is used chiefly when starting a train, or when a heavy pull is necessary, and requires the greatest adhesion, but when running quickly, or hauling light trains, the normal weight of the driving wheels, as they bear on the lower ones, give all the adhesion needed.

In its operation the "Fontaine" differs from an ordinary engine in the fact that in the latter the fulcrum of the applied force is at the tread of the wheels in their contact with the rails, and its power is given out at the crank pin when that is above the axle, and on the front cylinder head, and thence to the axle when the crank is below it; whereas, in the "Fontaine," the fulcrum of the applied force is constantly at the axle of the drivers, and the power given out is continuously at the perimeter of the drivers, at the points in contact with the friction wheels, the effective power being the same as would be were the drivers and friction wheels geared with spur teeth.

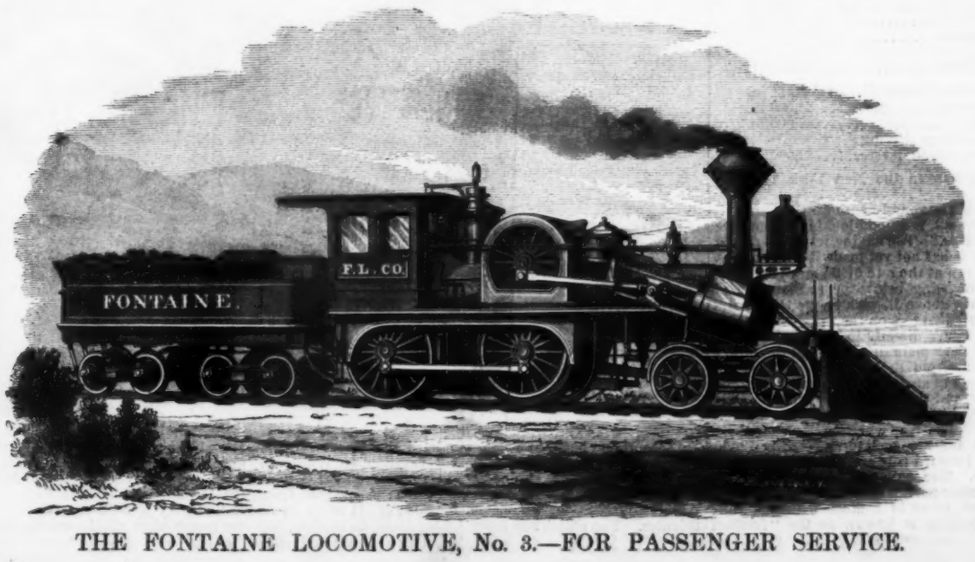
Paradoxical though it may appear, the "Fontaine" is, in reality, a stationary engine, so far as its machinery is concerned, but by the interposition of the auxiliary wheels effecting a junction with the drivers and the rails, the engine becomes at once a locomotive or moving force.

An investigation of the power of such an engine necessarily requires a *modus operandi* different from that of an ordinary engine, inasmuch as the peculiar combination of the wheels is a departure from the usual practice and introduces a principle for which there has been no precedent nor any regular formula established.

The power given out at the perimeter of the driving wheels revolving around their axle as a fixed center or fulcrum, as in the case of the "Fontaine," is precisely equal in effect as though the wheels ran upon rails, and the power was concentrated and given out at the crank pin, but with this distinction, that in addition to the usual power, there is a re-enforcement through the medium of the auxiliary wheels, which fact, unfortunately, appears to be somewhat misunderstood, and, therefore, it will be well here to try to make that point clear. Preparatory, however, to taking up the point as represented in the "Fontaine," the principle involved will perhaps be more readily understood from the following illustration. Let us assume that the driving and auxiliary wheels are exactly of equal diameters, and that the driving wheels are made to revolve. The effect of this would be that in one revolution of the drivers the lower



THE FONTAINE LOCOMOTIVE, No. 1.—FOR PASSENGER SERVICE.



THE FONTAINE LOCOMOTIVE, No. 3.—FOR PASSENGER SERVICE.

wheels also would make one revolution, and travel on the rails a distance equal to the circumference of the wheels; and if a train of cars had been attached to the axle of the lower wheels, the train would also be hauled an equal distance. Now, the propelling force applied by the drivers at the top of the lower wheels, in consequence of the leverage there being twice that of the resisting force at the axle, would pull double the weight that evidently could be done were the same force applied in a direct horizontal line with the axle of the lower wheels.

The superiority of the "Fontaine" is based on the soundness of this principle of re-enforcement of power by the interposition of the auxiliary wheels; the tractive power, however, of such engines will necessarily vary with the relative differences in the diameters of the wheels, and the consequent leverages of the propelling forces, as compared with the leverage of the resisting force acting at the axle of the lower wheels. Now if we take the wheels of the "Fontaine," as in operation, the driving wheels being 72 inches, the friction wheels 56 inches, and the rolling wheels 70 inches in diameter, we have a combination which, under an equal speed of piston, will have the effect of increasing the progressive speed of the engine on the rails to that of an ordinary engine with driving wheels 90 inches, or 7½ feet diameter. This increase of speed, however, necessarily reduces, in a measure, the tractive power, in an inverse ratio with the resultant equivalent for the larger sized wheels, except that, as the applied or propelling force operates at 63 inches from the rails, while the resisting or opposite force acts at 35 inches from the same point, there will be a re-enforcement or theoretical difference of power equal to nearly eighty per cent. in favor of the "Fontaine" arrangement. It should be borne in mind, however, that the whole of this large excess of gain has never been claimed in practice, for the reason that a large portion of it is absorbed in the additional friction involved by the use and action of the extra wheels and bearings; but there is undoubtedly an advantage gained over an ordinary seven and a half foot single driver engine, equivalent to at least thirty per cent., which can be utilized to that extent either in the pulling of heavier trains, or running at greater speed with similar trains; or the speed may be equal, and there will be thirty per cent. less expenditure of fuel.

The novelty in the construction of the "Fontaine" has called forth from some scientific experts very peculiar criticisms with regard to its capabilities, but in no case has there appeared anything like a reasonable exposition given in which a fair comparison was made with an ordinary engine of equal resultant dimensions. In one mechanical paper, a distorted diagram was published, and an argument based thereon to prove the fallacy of the "Fontaine," but either prejudice, or the ignorance of the writer with respect to the action of the locomotive, was evident from the fact that, in comparing the propelling forces of the wheels of the "Fontaine" and an ordinary engine, he assumed in his calculations that the leverage forces had their fulcrums at the axle instead of at the rails. Thus the results deduced were as erroneous as the argument; for it is a well-known fact that all wheels in locomotives used for propelling purposes and running upon rails have their fulcrums at the rails, while the distances to the centers of their axles, as measured from the rails, are, taken alternately with the backward and forward strokes of the pistons, either the long or short arms of the propelling leverages.

A careful investigation of these forces will prove the theory herein set forth, and will, without any doubt, confirm the superiority of the "Fontaine" as a combination for speed and power over any other existing type of locomotive.

JOHN ORTTON,
Canada Southern Railway.

St. Thomas, Ont., October 12, 1881.

THE FONTAINE LOCOMOTIVE.

IN addition to the engravings of engines Numbers 1 and 2, given on our first page, we also present an enlarged illustration of Number 1. Engines Numbers 1 and 3 are designed for passenger service, and are now running. Engine Number 2, not yet completed, is designed for freight service.

The following are

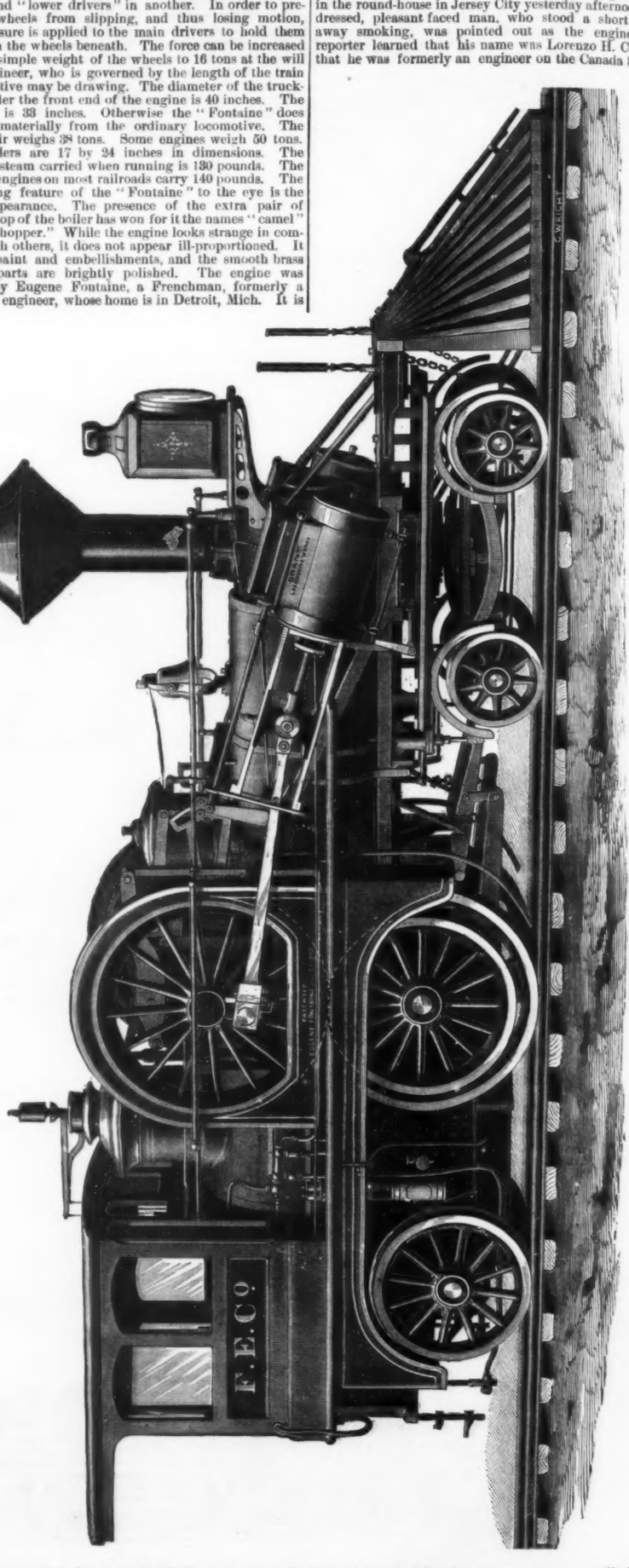
PRINCIPAL DIMENSIONS OF FONTAINE FREIGHT LOCOMOTIVE, NO. 2.

Cylinders	17x24 in.
Diam. of upper driving wheels	60 "
" friction	70 "
" lower	78 "
" truck	40 "
Wheel base	23 ft. 4 in.
Diam. of boiler (small course)	48 "
No. of tubes	160
Length of tubes	11 ft.
Diam. " (outside)	2 in.
Length of fire box (inside)	72 "
Width " "	35 "
Grate area	17½ ft.
Heating surface in fire box	112½ "
" " tubes	921 "
Total heating surface	1,033½ ft.
Height of center of boiler above rail	5 ft. 11 in.
Weight on driving wheels	34,500 lb.
Total weight of engine	82,000 lb.
Increase of friction between driving wheels through compound levers	32,000 lb.

We quote the following from the New York *Times* of October 18, 1881:

Standing in a "stall" in the round-house of the Pennsylvania Railroad, in Jersey City, is an odd-looking locomotive bearing the name "Fontaine." The engine was constructed for speed, and, although it has not yet made its trial trip, it is expected that it will run at the rate of 90 miles an hour. The machinery instead of being below the median line of the boiler is almost entirely above it. There are three pairs of driving-wheels, but only two rest on the rails. The third pair are on top of the boiler directly in front of the cab. These wheels are termed the "main drivers," and the power is communicated to them from the cylinders. The steam chests and cylinders are set at an angle of about 45 degrees, on the sides of the boiler, and the crank rods run up to the "drivers." The lower driving-wheels are different-sized and are not connected. The rear wheels, which are only 4½ feet in diameter, in the nomenclature of railroad men are the "ponies." The forward pair are called the "lower drivers," and are double. The main part of each wheel is 6 feet in diameter. The other part, which is a separate wheel, inasmuch as it does not come in contact with the rail, although in the solid casting, is known as the "friction wheel." It is 4½ feet in diameter, and is supplied with a steel tire the same as the others. The "main drivers" stand upon the "friction wheels" and transmit the motive power to them. The large wheels rolling upon the smaller ones give the speed. There is no gearing whatever. The "main drivers" run in one direction, and turn the "friction wheels" and "lower drivers" in another. In order to prevent the wheels from slipping, and thus losing motion, steam pressure is applied to the main drivers to hold them down upon the wheels beneath. The force can be increased from the simple weight of the wheels to 16 tons at the will of the engineer, who is governed by the length of the train the locomotive may be drawing. The diameter of the truck-wheels under the front end of the engine is 40 inches. The usual size is 33 inches. Otherwise the "Fontaine" does not differ materially from the ordinary locomotive. The whole affair weighs 38 tons. Some engines weigh 50 tons. The cylinders are 17 by 24 inches in dimensions. The amount of steam carried when running is 130 pounds. The passenger engines on most railroads carry 140 pounds. The only striking feature of the "Fontaine" to the eye is the general appearance. The presence of the extra pair of wheels on top of the boiler has won for it the names "camel" and "grasshopper." While the engine looks strange in comparison with others, it does not appear ill-proportioned. It is gay in paint and embellishments, and the smooth brass and iron parts are brightly polished. The engine was invented by Eugene Fontaine, a Frenchman, formerly a locomotive engineer, whose home is in Detroit, Mich. It is the second one built, and was completed about a month ago. It was constructed at the Grant Locomotive Works in Paterson. The first engine is now running on the Canada Southern Railroad. In May last it drew two coaches from Amherstburg to St. Thomas, a distance of 111 miles, in 98 minutes. The entire run from Amherstburg to Buffalo, 235 miles, was made in 235 minutes, including stops for coal and water. Among those on board the train were William H. Vanderbilt, and J. H. Rutter, of the Central Hudson Railroad, and W. P. Taylor, General Manager, and W. E. Carroll, General Superintendent of the Canada Southern.

While a reporter of the *Times* was inspecting the engine in the round-house in Jersey City yesterday afternoon a well-dressed, pleasant faced man, who stood a short distance away smoking, was pointed out as the engineer. The reporter learned that his name was Lorenzo H. Clapp, and that he was formerly an engineer on the Canada Southern. He said he would be glad to explain the peculiarities and merits of the engine, and told the reporter how the machinery was constructed and how it operated. He said the locomotive had been drawing a work-train on the Erie Railway for a week past. It was set at hard work to take the rough edges off the machinery. Engineer Clapp spoke



THE FONTAINE PASSENGER LOCOMOTIVE, No. 1.—BUILT BY THE GRANT LOCOMOTIVE WORKS, PATERSON, N. J.

of the engine as No. 2, and the one on the Canada Southern as No. 1. He thought No. 2 superior to the other in some respects. He let it out two or three times on the road, and attained a speed of 75 miles an hour. The reporter asked how it behaved.

"It ran like a bird and rode like a parlor car," replied Engineer Clapp with enthusiasm. "I want to tell you," he added, "that I can go faster on No. 2 than any man in the world."

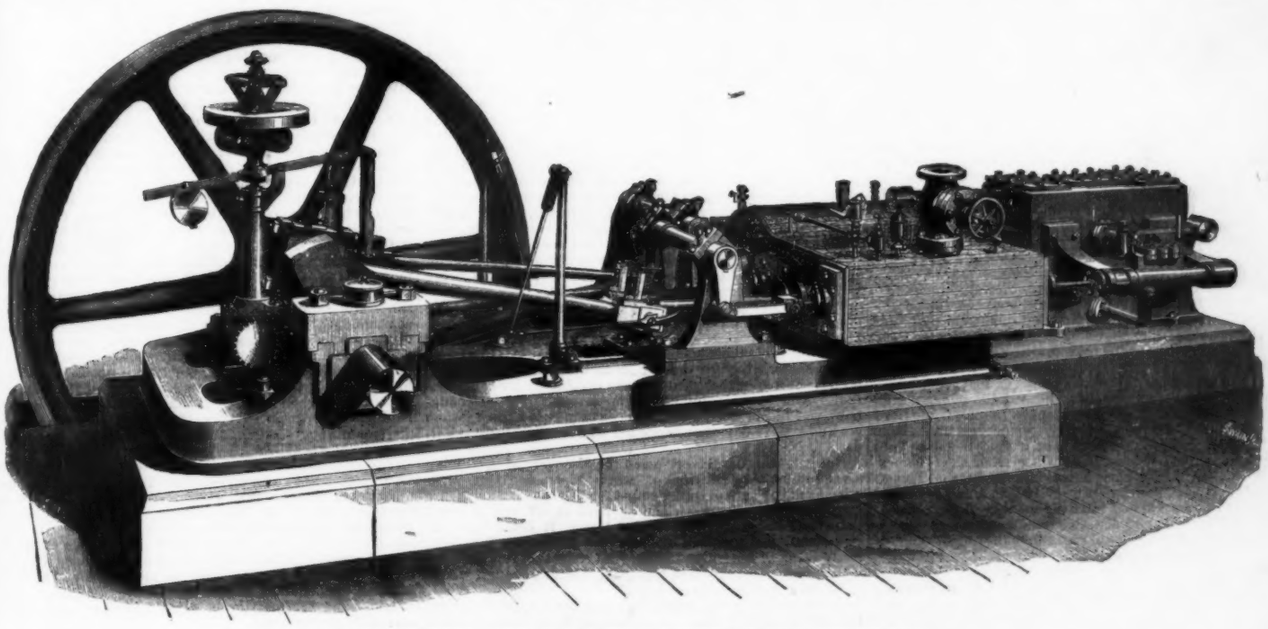
"Isn't the danger increased by running fast?"

"I don't think it is. The engine hugs the rail and is as steady as a clock."

The reporter learned from Mr. Fontaine that the trial trip would be made in a very few days. No. 2, if the expectations of the inventor are realized, will run between Jersey City and Philadelphia. The use of the engine for a year or so will be given to the railroad company. The cost of the Fontaine engines will not be much more than that of the common style.

IMPROVED COMPOUND ENGINE.

THE motive power for the woolen machinery lately exhibited at the Crystal Palace, London, was supplied by the compound condensing engine which we illustrate. The cylinders are 14 inches and 24 inches diameter, and 2 feet 6 inches stroke. The air pump bucket is 8 inches, and the flywheel 15 feet in diameter. The driving strap is 80 feet long and 18 inches wide, and the driving pulley is 6 feet in diameter. The engine is placed in one of the bays on the north side of the Palace near the orchestra, and it drives a lay shaft beneath the floor and behind it, from which motion is given to all the spinning and carding machinery by belts coming up through the floor. The engine is a very fine piece of work, substantial, and of excellent finish. The condenser is of the ordinary jet type. The variable expansion is effected by a modification of Pius Fink's well known link gear, which is, in our opinion, far superior in performance on the whole to the modified Corliss gear fitted to the somewhat similar engine exhibited at Paris by Messrs. Galloway & Sons in 1878. We may add that in this view the firm coincide, and they sell at least twenty engines with the Fink gear for one with the instantaneous cut-off. Such an engine as that at the Crystal Palace, with Galloway boilers, is guaranteed by the makers not to use more than two pounds of coal per indicated horse power per hour, the boiler pressure being 70 pounds, and the speed 70 revolutions, or 350 feet of piston per minute. The Crystal Palace engine, under these conditions, indicates 125 horse power, but several similar engines are doing 140 horse power. Messrs. Galloway & Sons have made a very large number of these engines, which, being self-contained, meet with great favor abroad.—*The Engineer.*



IMPROVED COMPOUND CONDENSING ENGINE.

INFANCY AND CHILDHOOD OF THE STEAM ENGINE.

By C. M. PERCY, M.E.

A PUBLIC meeting was lately held in the Museum, Warrington, to open a new session of the School of Science. Mr. C. M. Percy, M.E., F.G.S., of Wigan, delivered an inaugural lecture at Warrington on "The Infancy and Childhood of the Steam Engine." Large diagrams were hung upon the walls illustrating the following mechanical arrangements of olden times: A fire engine for raising water by compressed air, a clock valve, a jet of steam supporting a sphere, and the famous Hero steam engine, all taken from the "Pneumatics of Hero," De Caux's fountain caused by steam, Branca's arrangement of steam machinery for pounding drugs, Lord Worcester's "water commanding engine," Guericke's experiments on atmospheric pressure, and the engines of Savery and Newcomen, all the diagrams having been specially prepared for this occasion.

Anything connected with the rise and progress of the most wonderful mechanical arrangement which the world has ever seen, the steam engine, is full of interest in a practical community. To the rise of steam we owe almost everything practical that we are or have. By its aid we traverse great tracts of country with ease and expedition, although the distance amounts to many thousands of miles; under its influence mighty vessels plow the ocean wave and form links in a chain connecting continent to continent, and indeed putting a girdle round the earth, and to its power we are indebted for the opening of many new industries, and for the immense development of others which otherwise must long ago have ceased. Without it our mines could not be worked, our iron, in which particular branch Warrington stands so pre-eminent, could not be manufactured, and our mills and factories and foundries could not exist. We often hear, and perhaps as often repeat, the remark that England's greatness is largely to be attributed to its coal and iron. But we could not get the one nor make the other were it not for the means of production and manufacture which the steam engine so lavishly places at our disposal. We might, although in possession of abundant materials, be as poor as our predecessors, the ancient Britons.

To many, the whole rise and progress and history of the steam engine is comprised in the names and lives of two men, James Watt and George Stephenson, the former being the "all-in-all" of the stationary engine, which we know so well at our iron works and mills and collieries, and the latter the "alpha and omega" of our iron horse, the locomotive, which has caused our own and all other civilized countries to be covered with a perfect network of railways. No man in his sober senses would attempt to lessen the transcendent merits of these two eminent men, but we purpose dealing with engineering as it was in times long before these two benefactors of the human race saw the light. We are too apt, especially in engineering matters, to come to the conclusion that all the great discoveries have been made within our own little lives, and it does us good, at times, to ponder over the fact that long before we became inhabitants of this terrestrial sphere there were men who were indeed giants in intellect and renowned for their inventive genius. We purpose, at this time, confining our remarks to the history of the stationary steam engine. The infancy and childhood of the locomotive is just as full of interest, and at some future time possibly may occupy our attention.

HERO.

A knowledge of steam and of its immense power must have existed in very early times. Powers which philosophers and magicians were said to have possessed and great works which we know to have been executed can be understood well enough if it be granted that steam power was used. Unfortunately, there is great scarcity of authentic records of these ancient times, and this is to be attributed not at all to the fact that the ancients gave no honor to inventors of the useful arts, but rather from the blind excess of admiration which led heathen nations of remote antiquity to treat their memory with divine honors, and their real history has, in consequence, been lost amidst the mists of antiquity. In more recent times, but still ancient, engineers were neglected by historians from a prejudice against practice, as being inferior to philosophy, and this kind of feeling operated even as far on as the middle ages.

The earliest written work on mechanism in which steam is used as a motive power is contained in the "Pneumatics" of Hero, of Alexandria, an engineer who flourished 200 years B. C. This work has had many translations, but the most recent, and probably the best, is one undertaken by Mr. Bennet Woodcroft, since deceased, who had the invaluable assistance of Principal Greenwood, of Owens College. This translation, published in 1851, was dedicated to Prince Albert. It treats of the expansion of steam, and describes the slide valve, the spindle valve, and the common clack, and illustrates the application of a metallic piston to a metallic cylinder. It contains diagrams and descriptions of nearly 100 inventions, which would now be classed under the head of mechanical engineering, and all so clearly described as to leave no doubt of an advanced knowledge among the ancients of that class of mechanism out of which the steam engine has been structurally compounded. The difficulty that occurs to the reader of Hero's "Pneumatics" is that, writing 200 years before the Christian era, he says, in his preface, that he has "thought proper to arrange in order what had been handed down by former writers, and add thereto his own discoveries;" but he does not point out in any part of the book which inventions are his own, and which belong to former writers. We must fain content ourselves, therefore, with the fact that considerably more than two thousand years before James Watt was born not only were steam engines of a kind in existence, but circular motion was obtained, and valves and pistons and cylinders were in use. Hero's idea was that "water, when consumed under the action of fire, was transformed into air." In this particular respect perhaps his knowledge was scarcely as far advanced as our own, but he seemed to understand that "air was matter," and his ideas as to a vacuum, written at so remote a period, do him great credit. Hero says: "When they wish to fill with water the round medical glasses which have long necks, they suck out the air which is contained in them, and closing the orifice with the finger, they invert them in the water, and on removing the finger the water is drawn up into the vacuous space, in contradiction to the usual law of fluids."

DE GARAY AND PORTA.

A very long time had to elapse after the death of Hero before further progress was made with the steam engine. The Romans were a great race of warriors, and possessed many remarkable orators, but they did little for the mechanical arts, and nothing for the improvement of the steam apparatus. It was not till the dawn of knowledge succeeded the darkness of the middle ages that the light reflected from the works of Hero and the older mechanicians rekindled the flame of mechanical invention. Hero's works were read with eagerness, edition after edition was published, and formed the popular productions of the young art of printing. The flame first lighted in Italy, where translations and editions rapidly succeeded each other. In one single century, the sixteenth, nine editions were issued, and, as was to be expected, the seeds of mechanical knowledge so widely sown, some of it fell upon rich soil and ultimately brought forth fruit with increase. Porta, in a work which he wrote in 1601, seventeen centuries after Hero's death (what a lapse of time in which, so far as records go, no progress has been made!), explained that "the condensation of steam within a closed vessel may be made the means of producing a vacuum, and thereby causing water to ascend and fill the vessel."

Before this, in 1543, when Spain was in the meridian of her power, the transporting of her armies across the ocean became of great importance, and one of the naval captains, named De Garay, proposed to propel vessels by steam. It is somewhat remarkable that, although the early attempts at improving the steam engine were so much identified with ships, the stationary engine had proved itself a great success, and was extensively used long before steam power was successfully applied at sea. De Garay made a trial at Barcelona before the Spanish court, with a vessel of 200 tons burden, and his experiment was so far attended with success that the vessel was propelled at a speed of three miles an hour. No particulars have been handed down of how the motion was effected, and at the time the whole appliance was kept a secret; but from the fact of there being a boiler on board to generate steam, we may safely conclude that De Garay simply allowed a jet of steam to act upon the paddle wheels.

SOLOMON DE CAUX.

The spirit of invention aroused by the first translation of Hero's book did not confine itself to the country in which the books were first disseminated, but spreading itself gradually northwards displayed itself in the efforts of Solomon De Caux, who had come to England in 1612, and was employed by the Prince of Wales, afterwards Charles I., to lay out gardens and design grottoes, fountains, etc., around his palace at Richmond. In a book which De Caux wrote, he said that "the violence with which water is dissolved into air by means of fire is very great, and that a ball of copper containing water if placed upon a fire would surely burst." De Caux afterwards shows how a jet of water may be made to rise above its level and play in the air by means of fire. Our ancient Hero had, in his time, made use of a somewhat similar appliance for raising water, but instead of using heat and making the water thus raise itself, Hero used compressed air as a means of forcing the water up. De Caux was a Frenchman, born in Normandy, and in dedicating his work to the French monarch described himself as one of his subjects. After leaving England he lived for a while in Germany, but finally returned to France, and this remarkable personage in engineering history died in his native land in 1630.

BRANCA.

In 1629, just a year before the death of De Caux, an eminent Italian architect and engineer was distinguishing himself by his actual constructions of steam engine arrangements. Being also distinguished as a physician, he used a rotary steam engine for grinding his drugs. He simply impressed by a jet of steam a revolving motion on the

vanes of a wheel, and this, communicating with a series of toothed wheels, gave motion to a series of pestles in mortars. About this time there were no end of curiosities of mechanical invention. Perpetual motions were very common, wings for enabling men to fly in the air, mechanical chariots for a similar purpose, conveyances to the moon, and engines for making continual and cheap music by mills or by fire, for rocking cradles or turning spits, were favorite subjects of design.

THE MARQUIS OF WORCESTER.

The era of curiosities of mechanical contrivances was passing away, and the same principles were to be applied to more useful machines for the advancement of the human race. Edward Somerset, Earl of Glamorgan and Marquis of Worcester, has been credited with having invented and constructed the first real useful acting steam engine. To understand his claims to this distinguished position, which have been disputed in many quarters, we must first for a moment consider what a steam engine does in our own day. It performs work. And what is work? Either the raising weight through height, or, putting it more generally, the overcoming resistance. A pumping engine raises water, a colliery winding engine raises coals, a ventilating engine raises air. But a marine engine propelling a vessel overcomes the resistance of the water, and a locomotive engine drawing a train overcomes the friction of the rails and of the moving mechanism, and so performs work. Still, the simplest and perhaps the most general work which is done is the raising weight through height. Hero had an engine which obtained direct rotary motion, and he had a toy in which a sphere was supported by steam, and also an arrangement for raising water from a fire engine by manual labor. De Garay and Branca caused wheels to revolve by the action of jets of steam, and De Caux made fountains by steam being generated in a vessel and forcing a jet; but Lord Worcester actually constructed a machine to which he gave the high-sounding name of "the water-commanding engine," and which did actual and useful work by raising water from a lower level and depositing it upon a higher level; and engines of the present day—at least those used for pumping—do no more.

The life of the Marquis of Worcester forms one of the most romantic chapters of English history, and affords a tissue of the most violent contrasts, exceeding any that have ever been experienced by any other scion of English nobility. He was a man of rigid honor and probity, remarkable also for his modesty, virtue and genius, in an age not distinguished for many virtues, and an age notorious for numerous vices. He was the favorite of his sovereign, although not in favor at court, and the esteem which raises most men proved his certain ruin. He was obliged to flee his country, and returned only to be imprisoned, and on his release from prison was allowed £3 sterling per week, as an allowance on which to live, out of his princely estates. This unfortunate man, whether under monarchy or commonwealth—sovereign or protector—was certain only of unjust treatment and confiscation, although he was unquestionably, from an engineering point of view, the greatest man of his age, and almost indisputably the inventor of the steam engine. Possessing inventive genius of the highest order, he was deemed a mad enthusiast, simply because he was in advance of the time in which he lived. He was called quack and imposter by men incapable of understanding the value of his creations. In our time, fortunately for us and for his memory, we are able to appreciate his great ability, and properly place him in the foremost rank of the world's most eminent men.

It has been doubted whether the "water-commanding engine" ever had an existence, except in the mind of Lord Worcester, and in the book which he wrote; but undeniable proof has been presented that such an engine made by him was actually employed for raising water from the Thames. Lord Worcester, during his imprisonment in the Tower, compiled a book giving a list of 100 of his mechanical inventions. It was prepared after the manner of the "Pneumatics" of Hero, but differs in two important respects. Hero did not distinguish between his own inventions and those of others; Lord Worcester is careful to inform his readers that he published no inventions except his own. The other point is that Hero's work was well illustrated, each invention having its own descriptive diagram, whereas, Lord Worcester's book did not possess a single sketch, and we have had to gather what his mechanical inventions were from mere written descriptions, written, too, in most stilted language.

This publication, which was issued about 1663, was entitled "*A Century of the Names and Scantlings of such Inventions as at present I can call to mind.*" The earnestness of this eminent inventor in his work is shown in one fact, that he had in his employ, for a continuous period of thirty-five years, the most distinguished mechanic of his time, and provided him with workshop appliances at an expense of £10,000. In fact, he devoted a long life and an enormous fortune to the work of inventing a machine which, although it was to bring him no credit during his life, was destined to have the most powerful influence throughout the world. In his own words his steam engine is described as "Invention sixty-eight, an admirable and most forcible way to drive up water by fire; and having found a way to make my vessels so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a fountain forty feet high. One vessel of water rarefied by fire driveth up forty vessels of cold water, and the man that attends to the work is but to open two cocks, that one vessel being consumed, another begins to force and refill with cold water, and so, successively." The engine was further described as one which "would work backward or forward, upward or downward, to and fro, would make one pound raise a hundredweight, would raise silently a column of water one hundred feet high and two feet in diameter, would drain mines, furnish cities with water, and be under the control and influence of a child."

This was written more than two centuries ago, and allowing for the bombastic style, and something for exaggeration, how does it compare with what is now actually being performed every day? Engines do drain mines hundreds of yards deep, and could do so if need be thousands of yards. Engines do supply towns and cities with water sufficient for populations far beyond the idea of population 200 years ago. The slight movement of a piston through a few inches or a few feet will raise water through a hundred times the distance, and the strength possessed by a child can set in motion great pumping engines or marine engines or locomotives. Those who lived in his own time might and did call Lord Worcester an idle babbler and a mad enthusiast. We now know him to be the inventor of the steam engine, and consequently one of the most illustrous men of any time, and a benefactor to the whole human race.

ATMOSPHERIC PRESSURE.

Up to this time, whatever work was performed was under the influence of direct steam pressure acting upon water and forcing it up, but now another principle, that of atmospheric pressure, was to become thoroughly understood, and be made the means of taking another step in advance with the steam engine. Guericke, in 1654, made some remarkable experiments—remarkable in their being made at all, but much more remarkable on account of their success, and he proved that atmospheric pressure could be used for raising a column of water or for depressing a piston. He proved that having an empty space into which water could run, a space free from everything, air included, the pressure of the atmosphere would be equal to supporting a column of water 30 feet high in such a space. And he also proved that having a similarly empty space on one side of a piston, the atmospheric pressure upon the other side would be equal to 15 lb. per square inch area of piston.

Guericke showed first that the pressure of the air on the water in the vessel at the bottom forces the water up the pipe about 30 feet high, the pipe having previously been exhausted of air into the receiver above. If the vacuum could be made perfect the water would rise 34 feet, but it is always considered a good result to produce a column of 30 feet. Second, that if a piston was placed in a cylinder which had previously been exhausted of air below the piston, the pressure of the atmosphere above the piston would overcome the efforts of many men pulling at ropes to try and raise it. Third, that the pressure exerted by the atmosphere may be measured by a scale. Let a piston be attached to one end of a beam, and an ordinary scale pan attached to the other end. The pressure of the atmosphere per square inch of piston area multiplied by the area is the force at one end of the beam, and the weight in the scale pan at the other end will indicate what the pressure is.

SAVERY.

An Englishman named Savery introduced this principle of atmospheric pressure in the engine which he used in 1697. In Worcester's engine steam in one vessel acted upon water in another vessel and raised the water to a higher level, and then the water vessel had to be charged again. But in the Worcester engine these vessels must either have been placed at a sufficiently low level for the water with which they had to be charged to run in, or else they must have been filled by manual labor, because no provision is made in the water-commanding engine for raising the water into the vessels. But Savery, by the introduction of atmospheric pressure and condensation, was enabled to place his engine 30 feet above the level of the water which was to be lifted. His principle of action was, simply, that having forced all the water from a certain vessel, and it being therefore empty of water and full of steam, the steam was shut off, and the steam within the vessel condensed, thus forming a vacuum, and in consequence of atmospheric pressure, water would run up a column of 30 feet and charge the vessel again. By having two water vessels Savery was always able to have his engine at work. While one vessel was being emptied under the influence of steam pressure the other vessel was being filled under the pressure of the atmosphere.

It is said in connection with Savery's engine that he did not obtain his knowledge of condensation and its advantages from the experiments of Guericke, or indeed from any one else, and this may well be believed, because Guericke's experiments, although dealing with atmospheric pressure, do not show how the vacuum was obtainable by condensation. And again, communication between various countries was not in the seventeenth century as it is now, when we know all to-day that happened all over the world yesterday.

But it is said that Savery owed the discovery of producing a vacuum by condensation of steam to an accident. "A wine-flask, being not quite empty, being thrown on a fire and producing steam, when he took it off the fire and immersed its mouth below cold water, it condensed the steam and filled the flask by atmospheric pressure." Savery, in speaking of his engine, says: "It raises a full bore of water sixty or seventy feet high, and if strong enough would raise water a thousand feet high."

Savery's engine was introduced at a most opportune time for having a fair trial. At this time English miners were experiencing great difficulty in clearing their shafts of the vast quantities of water which they were meeting at the considerable depths to which they had penetrated. And it had become a matter of vital importance to them to find a more powerful aid in that work than was then available. Savery entitled his engine "The Miner's Friend," and he holds the honorable position among engineers of being the first to introduce a really practicable and commercially valuable steam engine. It was used at a number of mines, and also for supplying water to towns, and on some large estates, and at country houses.

PAPIN.

Even Savery's engine was found insufficient for the requirements of the mining districts. It possessed two defects—first, the steam acted directly upon the water to be lifted, and consequently not only was there considerable waste of power through the direct contact of the water and steam, but the height to which the water could be lifted was limited by the steam pressure, and this in its turn was limited by the strength or rather weakness of the vessels. Endeavors had been made in some cases to get rather more work out of Savery's engine than it was qualified for, and the result was explosions and loss of life. This points out to us the second defect of Savery's engine, namely, the want of an appliance to prevent steam pressure rising above a certain point.

It is for us now, with all our valve arrangements, to wonder that they did not see the deficiency long before they did and supply it. There are, even in our most modern and most perfect steam engines, known deficiencies which will require all the talent of our rising generation of engineers to supply. Enough that the deficiencies of Savery's engine were realized, and for their improvement we owe a good deal to Papin, whose name will forever be identified with the safety valve, which enables us to determine above what pressure steam shall not rise; and also the piston, which has proved to be the most important part, or nearly so, of the whole steam engine.

NEWCOMEN.

It was not Papin, the foreigner, however, who really applied the piston in a useful form. It was a distinguished Englishman who first, in company with Savery, and afterward alone, made great improvements. With Savery's engine the height was limited, and as a column of water 10 yards high would require a pressure of 15 lb. of steam, we can understand that the height to which "The Miner's Friend" was limited, was very limited indeed. The only way out of the difficulty was to have a number of Savery's engines, one at each stage of the journey, and each lifting the water to a certain height. But this was found not only inconvenient, but unprofitable, and miners were in despair again. Newcomen placed at their disposal the engine which embodied the following new principles: Savery's engines were what we should term condensing steam engines, but Newcomen's was an atmospheric steam engine, so called, because no part of the work was done by steam pressure. Newcomen introduced the piston and cylinder, and although in these degenerate days, when we hear of such appliances as the injector, the ejector, and the pulsometer, we feel as if we were marching back to early times, we may be assured that the steam engine never could have been a success without the piston and the cylinder. Instead of the power depending purely and simply on the pressure of steam, it was made to be regulated by the area of the piston on which the steam acted. He also introduced jet condensation, applied internally, and in this made much quicker action possible, and paved the way for the after-introduction by Watt of his separate condenser. He applied the beam and enabled the pump to be placed at one end and the cylinder at the other, and by making his pump small enough and the cylinder large enough, could raise the water to any height by mere atmospheric pressure. He also arranged valve mechanism for opening and closing the valves, and thus made the engine self-acting.

The action of Newcomen's engine was simple enough. The cylinder was open to the atmosphere at the top, and closed altogether, except for its connection with the boiler, at the bottom. The beam was above and had at one end the pump, at the other the piston, so that when one ascended the other descended. To make an upstroke of the piston no force was needed, because the pump rods were heavy enough to pull the piston up and allow the cylinder to fill with steam below the piston. Then the jet of water was turned on to the steam and condensed it, creating a vacuum below the piston which enabled the atmospheric pressure above the piston to draw the pump up, and in so doing raise the water. This engine did excellent service, gave the mines of England another term of working life, and, although in its turn it proved unequal to requirements, the greatest compliment we can pay to Newcomen is to say that the success of his engine made the requirements with which afterward it was not able to deal.

And this was the engine to which James Watt turned his attention in 1759, at the University of Glasgow, and which was the immediate cause of his commencing a line of work which was to immortalize himself, and make almost perfect the most useful servant mankind could wish to have.

Beyond this point we do not propose to carry this history. Commencing, as we have done, to speak of a time before the Christian era, the infancy and childhood of the steam engine covers the whole period till Newcomen. But when Watt, whose name is so well known to us all, comes on the scene, the manhood of the steam engine commences, and with that period of its existence it is not our intention at this time to deal. Nothing that has been said need lessen for a moment the esteem in which we hold those who have labored to make the engine more and more perfect in our times and immediately previous; but it may make us with advantage think more highly of those who played their part on the world's stage many centuries ago. James Watt has done more for the steam engine than all those who preceded him and have succeeded him combined; but he would be the first to admit that the men whose work we have touched upon roughly and briefly—Hero, Porta, Branca, De Garay, De Caux, Worcester, Savery, Papin, and Newcomen—were all men of engineering eminence, and deserve the admiration of the world.

The development of the steam engine may be divided into three stages, namely—before James Watt, after James Watt, and James Watt's own inventions. It has been thought sufficient by the lecturer, and probably thought more than sufficient by the audience, to confine attention at this time within the period which ended when Newcomen passed away. To that early period we owe more than many of us are willing to admit, and the more we study the events of these bygone days, the better able we shall be to comprehend clearly the manner in which the steam engine has attained its present state.

THE PANAMA CANAL.

WE give a panoramic view of the Panama Canal as planned by M. De Lesseps. The general principles of the plan are now so well known as to need no detailed description, and the engraving will give a much better idea than columns of figures would. It shows the course and the relative positions of the rivers. It also shows the location of the big dam which is to turn the Chagres River.

A great deal of preliminary work is now being done at the canal in the way of surveying, boring, etc. They are also studying a way to dispense with a lock at Panama. The high tide at Panama is 32 ft., and on the Atlantic side it is only 1 ft. 6 in. The problem presented by these differences is now being studied. They think the current will be very small, and that it will present no difficulties to be overcome.

These facts we gain from Mr. Prosper Huerne, an architect of this city, who has just returned from Panama, where he remained several months superintending the construction of buildings in one of the villages on the line. There will be fifteen or sixteen of these villages on the line. The first one Mr. Huerne laid out at Gabun and at the next station to that place. All the material for the building was procured in this city, and shipped down there ready to be put together. The mill work, etc., was all done here. Mr. Huerne took about forty American carpenters with him. Another village station will soon be established.

Each village has for buildings a large shed, store-houses, lodging-houses, an engineers' cottage, hospital, workmen's kitchen, dining rooms, foremen's lodgings, bakery, water tank, ice house, etc. The villages are arranged precisely alike. Every possible means has been provided to keep the men in good health. The buildings are well ventilated, and all the sanitary requirements are well cared for. The design of the buildings and the general plans were by Mr. Huerne, and were adopted without any demur. Water is brought to all the dwelling houses, and they are all properly sewered.

In the panoramic view, Figs. 1, 2, 3, 4, 5, and 6 show stations in the canal where vessels turn out to let others pass. Fig. 7 is the dam for controlling the waters of the upper Chagres; length, 1,500 meters; breadth, 960 meters; height, 45 meters. Figs. 8, 9, 10, and 11 are valleys inundated by the rivers Chagres, Chilibre, Pegueni, Gatuncillo; height of the inundation, 38 meters; volume of the water, 1 milliard

cubic meters. Fig. 12, lower Chagres, separated from the upper by the levees of the canal. Fig. 13, discharging ditch formed by the bottom of the levees. Fig. 14, cut of the Culebra, height, 87 meters; length of the canal, 74 kilometers —49 being in plains, 28 in the rocks; breadth—bottom, 22 inches in plains, 24 meters in rocks; water level, 50 meters in plains, 28 in rocks; depth, 8 meters—50 in plains, 9 meters in the rocks; shortening of distances by the canal, from 1,400 leagues to 4,800 leagues.

The survey and staking of the line of canal has been accomplished by two corps, which has employed a large number of natives. The check surveys and leveling of the railroad have been finished from Colon to a point beyond Pedro-Miguel on the Pacific side. The bench-marks of the leveling have been engraved on the abutments of the railroad bridges and also on the mile stones at the necessary points.

The leveling of the longitudinal section of the large canal and likewise the cross sections already laid out have been connected with the line of the railroad which serves as a base, the level of which commences at the ocean and which was determined by the first observations made by the hydrographic corps.

The staking out of the work in the mountain regions is nearly completed. There still remains, however, a small amount of leveling of ditches between Obispo and the Chagres River and the crossing of the neighboring summits, the timber from which has been cut down in order to facilitate triangulation. Two corps are at work on the survey of the dam for the reservoir at the head of the upper Chagres.

A corps has been organized to run a line across the mountains by way of Upper Obispo and the river Pedro-Miguel, although the reconnoissance made of this district last year seemed to show that this passage was not as favorable as that of Culebra. The engineers consider that it is necessary to verify this by correct level, in order that no possible economy may be overlooked in the definite staking of the canal. Another line is run from the mouth of the canal near Panama to an embouchure on the Rio Grande.

Instruments will be placed on the Chagres at Gamboa for the purpose of observing the velocity of the current and the rise and fall. Similar observations will be made on the Gatuncillo and the Obispo, affluents of the Chagres, and on the Rio Grande. At Colon surveys are being continued in order to determine the mouth of the canal, and also works for the protection of the harbor.

About fifteen hundred soundings have been taken in the immediate neighborhood of the line of the projected mouth of the canal. Samples of the bottom are taken with each sounding, with a view of determining its hardness. The bottom of Colon bay is covered with mud, which is in certain places mixed with sand, and near the shore pure sand is found mixed with small shells. The rest of the bay is bordered with a belt of coral. The softest mud is at the mouth of the Folkes River. This deposit was originated by the stoppage of the current around the island, owing to the construction of the railroad embankment. It can be dredged out, however, if it is decided to make there a harbor of refuge for deep-water ships and coasters.

The temperature varies in Colon between a maximum of 30° C. and a minimum of 21° 9' C. The daily averages are between 29° 4' and 26° 2' C.

These meteorological observations have been regularly made at Colon at the mouth of the Rio Janeiro (Pacific) and at Gamboa (the central point on the Chagres). Borings have been made along the line of the canal across the Culebra to determine the character of the ground. Six shafts have been sunk between kilometric points 51 and 56. The deepest, which is 50 meters deep at station 51, struck hard rock at 43 meters. The next one, at station 52, at 23 meters, struck a bench of very hard rock of 2 meters and more in thickness. Then it ran into a conglomerate, and then a second bench of very hard rock was struck. Finally, they passed through a very thick bench of very hard rock, which they struck at 31 meters.

The other shafts have only indicated an argillaceous conglomerate. Finally, to determine the character of the ground at Emperador, a large shaft having a sectional area of 10 meters, has been sunk. At a depth of 8 meters they came across angular pieces of dolorite embedded in a mass of colored sand.

The shafts are timbered and have two compartments. Six houses have been built at Emperador for the corps of miners. A large carpenter shop, blacksmith shop, etc., have been put up for convenience in the shaft work. The frame work and machinery for the sinking to 100 meters have been received and housed in. At some of the shafts palm roofs only have been put up to protect the men from the rain and the rays of the sun.—*Min. and Scien. Press.*

A RECENT ADDRESS BY CAPT. EADS BEFORE THE BRITISH ASSOCIATION.

IMPROVEMENT OF THE MISSISSIPPI, AND THE TEHUANTEPEC SHIP RAILWAY.

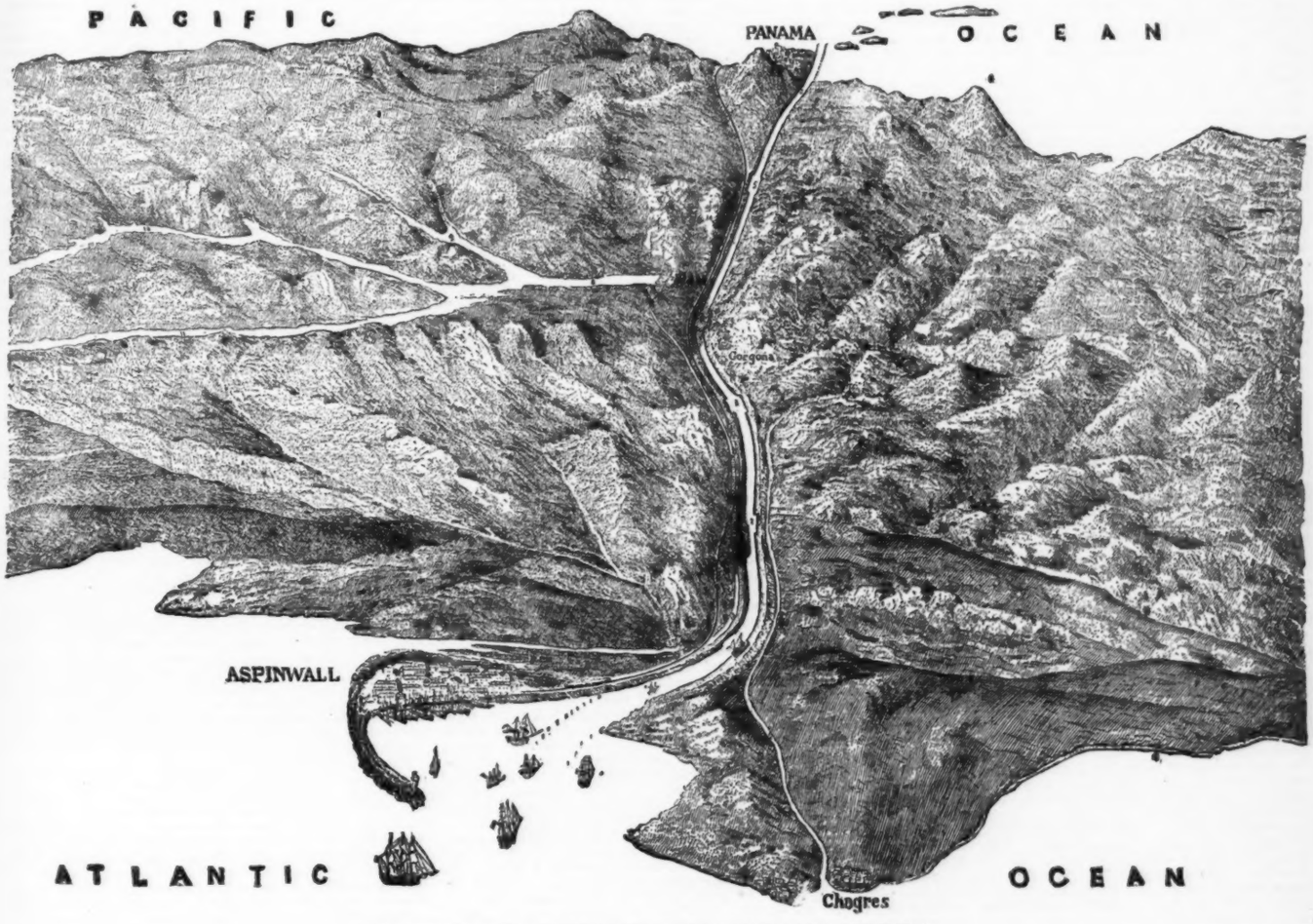
AMONG the invited guests at the meeting of the British Association at York was Captain James B. Eads, C.E., the constructor of the St. Louis Bridge and of the jetties at the mouth of the Mississippi. At the meeting of Section G, over which Sir W. Armstrong presided, he was urged to deliver an address upon the improvement of the Mississippi, and also to speak upon the proposed ship railway across the Isthmus of Tehuantepec. Captain Eads replied that he was merely present for the day as a guest, and not expecting to have the honor of an invitation to address the meeting, he was totally unprepared to do so. However, being pressed, he consented to occupy half an hour of the time of the section in explaining the improvements of the Mississippi and another upon the subject of the ship railway. Notice was accordingly given on Thursday, that, after the President's address, Captain Eads would speak upon the above-mentioned subjects. The section met in the hall of the Corn Exchange, and at the appointed time, one o'clock, a large and attentive audience was present. Captain Eads, as already stated, delivered his address extempore, and not from a written paper. We give the substance of his remarks, and not a verbatim report of them.

Captain Eads said that the two works upon which he had been requested to speak were each of such importance and magnitude as to affect the commerce of the world quite as much as any other enterprise yet undertaken and executed. He then went on to say that for more than forty years many plans for the improvement of the Mississippi had been suggested and tried, but without success. The Mississippi in flood times discharged about 1,250,000 cubic feet of water per second, and brought down in suspension an enormous quantity of sediment. The slackening of the current upon entering the sea caused this to be deposited at each one of the mouths of the delta, so that in front of each a bar was formed. These bars advanced annually into the Gulf through the additions made to them by the frequent and heavy floods.

In 1873, the Government engineers proposed to construct a canal forty miles above the mouth of the river to the deep waters of the Gulf. The canal was to be about six miles long, but as the difference in the level of the river and Gulf is about six feet, it would have been necessary to lock the ships through the canal into the river. He (Captain Eads) opposed this plan, and urged the improvement of the mouth by means of jetties, and he was so confident of his success that he offered to deepen one of the mouths of the river (on the bar of which only eight feet of water then existed) to thirty feet, and to obtain a depth of twenty feet before any money should be paid to him. The jetty system was opposed on the ground that the sediment brought down by the river was chiefly pushed along on its bed by the current. He, however, contended that it was carried in suspension, and that the quantity which the water was capable of carrying was strictly regulated by the velocity of the current. To disprove this assumption, the opponents of the system quoted the results of careful examinations which had been made at two points of the river by Messrs. Humphreys and Abbot, to show that there was no relation whatever between the quantity carried in suspension and the velocity of the current, according to the diagrams published by Messrs. Humphreys and Abbot, to show graphically the results of their observations. He (Captain Eads) pointed out, however, that they had fallen into a strange error in comparing the velocity of the current per second with the quantity of sedimentary matter found in a single cubic foot of the water during a second of time. As there was no correspondence between these two quantities they assumed erroneously that there existed no correspondence between the velocity of the current and amount of sediment carried by it. Their mistake consisted in failing to compare the current per second with the quantity of sediment carried by the entire river during that second of time past the point of observation, instead of that contained in only one cubic foot of water. He took their own tabulated statement of results, and constructed a graphic chart showing the velocity per second, and the quantity of sediment carried per second, and the synchronism of the two was completely and thoroughly established, leaving no room for questioning the truth of the principle upon which he founded his hopes of success.

Captain Eads then explained briefly, with the aid of sketches on the blackboard, the location of the bar with respect to the mouth, and showed that as there were thirty feet of water at the point where the banks of the river terminated, and where the river was one thousand feet wide, the same depth of water could be made to exist two and a quarter miles out to sea (where the depth was then but eight feet and the width five thousand feet), if the volume of discharge were carried out between parallel jetties one thousand feet apart, over the crest of the bar into the deep water beyond. This was the plan, and it had proved eminently successful, for thirty feet of water was thus obtained two years ago, and since that time this depth had been continuously maintained.

Recently a commission of engineers was appointed by the United States Congress to determine the best method of improving the whole course of the river Mississippi, and three plans were proposed to effect this purpose. Thirty



PANORAMIC VIEW OF THE PANAMA CANAL.

thousand square miles of valuable land were liable to annual inundation by the flooding of the river, and this was partially prevented by what is known as the "levée" system—a system of dikes. The advocates of the "outlet system" claimed that if outlets were made and the flood waters were carried off by other channels to the sea, the height of the floods would be materially reduced. Another system which may be designated as the low water treatment of the river has been tried to some extent without beneficial results; it looked to the improvement of certain localities and parts of the river where the bars were most troublesome, but no permanent benefit could be secured by these systems for reasons which he (Captain Eads) then proceeded to give. A profile (section) was drawn upon the black-board, the base line of which represented the level of the Gulf of Mexico, and rising from this more and more rapidly a second line showed the slope of the river surface in flood time, and indicated the fall of the river from the higher to the lower level by which the current of the stream was produced. Captain Eads then went on to say that the chief element which resisted the flow of the current was the friction of the bed of the stream. The friction of water flowing through pipes or over the beds of streams increases with the increase of the surface in contact with the water, and does not follow the same law as solid bodies. The frictional surface in a pipe of four feet diameter would only be four times as great as that in a pipe of one foot diameter, but as the larger pipe would contain sixteen times as much as the smaller, the ratio of friction to volume would only be one fourth as great as in the smaller one. It is easily perceived, therefore, how the flow of the river is retarded by the wide places existing in its bed where the friction is so much greater. Hence to maintain sufficient velocity to carry the sediment on to the sea, it must have a steeper slope at these wide places.

He called attention to the fact that for the first two hundred and forty miles of its course the river was comparatively uniform in width, and the fall was less than two inches per mile, while in the next sixty-nine miles, it was nearly twice as great, and from this point to Cairo, eleven hundred miles from the sea, the fall was much greater; this was due to the great number of wide places and islands which existed in that part of the river, and if these wide places were reduced and made narrower, there would naturally be much less frictional resistance to the current, which being then accelerated would be enabled to carry off a much larger quantity of sedimentary matter, which would be taken up by the stream from its own bed, for the river flows over a bed formed of its own deposits. Every particle of sand lying in the bed, whether deposited yesterday or ten thousand years ago, was brought there by the action of the stream, and was left because of the inability of the current to carry it further. It was evident that as soon as a stronger current touched this deposit it would be again taken up and borne onward to the sea.

No engineer is able to permanently increase the velocity of the Mississippi; its normal velocity is that which enables it to carry its burden of sediment without loss or gain, and if accelerated beyond this, the quantity which will be taken up by the stream from the bed of the river will deepen the latter in exact proportion, and as this is made deeper the slope of the surface will be reduced. The dikes were now needed to prevent the floods from overflowing the banks. The contraction of the wide places, and the creation of uniformity of width in the river will lessen the friction, increase the velocity, scour the bed deeper, and thus not only remove the shoals, but lower the slope, and render the dikes useless. This was the system of improvement which he had been urging upon the country for five or six years, and it had been finally adopted by Congress; last session a large amount was voted to commence the construction of the initial works of the improvement. He had declared several years ago that the relation between the velocity of the current and the quantity of sediment carried in suspension was purely the result of the expenditure of force, and that no part of the force required to hold this sediment in suspension could be made to perform any other duty without leaving less force in the current to suspend the sediment; and that if a fishing net were drawn across the stream the friction of it would absorb sufficient force to cause the deposition of sedimentary matter below it. This experiment had in fact been tried in the Missouri River, and at the present time one of the means of building up banks to lessen the breadth of the river was by screens made of wire, with meshes one foot square, which were held across the bed of the river by bags of stone and kept in vertical position by empty barrels secured to the upper edge of the screen. As much as sixteen feet of deposit had been raised in one season of flood by this method. By using willow or wire screens the formation of new banks can be accomplished where the river is too wide, and in the course of a few years comparative uniformity in width may be attained. As the friction increases with a diminution of volume, it is plain that by abstracting a portion of the volume through outlets and draining off the flood water to the sea, the remainder of the river must flow more sluggishly because of the increased ratio of friction; additional deposits would, therefore, be thrown down in the bed of the stream and its surface slope would be increased, thereby rendering higher dikes to prevent overflow a necessity, but by confining the flood water within a uniform high water channel all the force of the current was conserved, the ratio of friction decreased, and a lower surface level is the inevitable result.

THE ISTHMUS SHIP RAILWAY.

Captain Eads then proceeded to the second portion of his address, and spoke of the projected ship railway as follows:

He said he would not occupy the attention of such an intelligent audience with any argument to show the importance of a trans-isthmian route across the American isthmus, but would call attention to the map of the isthmus. No doubt many persons would be surprised to learn that this isthmus between the two continents of America was fifteen hundred miles in length, or about two and a half times as long as Great Britain. It lies in the direction in which ships have to sail in the Pacific Ocean when going to the Orient, Japan, California, Oregon, the British Possessions, etc.; hence if they are made to cross the isthmus at Panama, which was near the South American continent, a ship would have from thirteen to fifteen hundred miles to sail along the Pacific coast before she came to Tehuantepec, where the isthmus joins the North American continent. It is at the latter point that the ship railway is to be constructed, so that a ship sailing from New York to San Francisco, for instance, would save by crossing at this point about fifteen hundred statute miles which would otherwise be necessary if the journey were made through the canal which Count de Lesseps is now constructing. The commerce from the Mississippi, if compelled to pass through the canal, on its way to China or California, would have to go nearly twice the length of the isthmus, adding about two thousand two hundred miles to its route.

He stated that Mexico had granted a remarkably liberal concession to aid the construction of the ship railway, and had given the company the right to obtain the aid of any foreign government, and in consideration of this assistance the company was authorized by the terms of the concession to discriminate in favor of the commerce of such government against that of all other countries except Mexico.

Captain Eads then explained that the first thing to be done in the ship transit would of course be to take the vessel out of the water and place it on the railway. He believed that the oldest plan known for doing this was by the method called in England the slipway; and in the United States, the marine railway. This consisted simply of an inclined plane and rails, on which a platform was lowered down into the water until it had reached a sufficient depth for the vessel to be floated over it; supporting blocks were then drawn under the various parts of the keel and bilges requiring support, and when this was done, power was applied to the platform, which was drawn, with the ship upon it, out of the water.

He would not discuss the question of the capability of the ship when fully loaded to bear this operation without injury, because numberless ships had been taken out of the water with their cargoes, without injury to either, both in this country and in America; and furthermore, he had the assurance of the ablest shipbuilders of the world that there was no danger in the proceeding. He believed that the simplest and most expeditious method of raising the ship would be by that known as the hydraulic dock system, an excellent application of which was to be seen at Victoria Docks, London, made by the eminent engineer, Mr. Edwin Clark. By this method a platform is suspended between a number of upright hydraulic jacks, on which platform is a section of the railway track consisting of twelve rails. When raised, this section of rails would form an extension of the ship railway. The cradle for carrying the ship is run on to this platform, which is then lowered down into the water by means of the hydraulic apparatus to a sufficient depth to float the ship over the car; an automatic system of supports is then drawn under the ship into the position necessary to properly sustain it. The platform is then raised until the rails upon it coincide with those of the permanent way on shore; locomotives being then attached, the ship is hauled across the isthmus.

On the blackboard Captain Eads sketched the wheels of the freight cars as used in this country and in America, and drew attention to the large space between the wheels of each car, in which other wheels might be placed to carry additional burden, if the curves of ordinary railways did not preclude their use. The weight of a ship, however, being more concentrated than that of a train of wagons, it was necessary to have the load carried by wheels placed closer together; and hence it was impracticable to have curves in the proposed ship railway. This must be constructed absolutely straight. Where it became necessary to alter the direction of the route it was done by means of turntables, on which the locomotives and car could be easily turned into the direction required. The surveys of the isthmus had shown that only two, or at most three, of such turntables would be required, and they had further shown that the steepest gradients would not exceed one foot in one hundred feet, and that these would only extend through one-sixth of the total length of railway, the others being not more than twenty feet to twenty-five feet per mile. The wheels to be used would be about twenty-six inches in diameter, and would be placed about three feet apart.

He had been told by the resident engineer of one of the largest English railways that some of the locomotives in use on that line imposed a weight of nine tons on each wheel when at rest. It was clear, therefore, that five tons could be safely borne by each one of the car wheels of the ship railway. If one of the large steamers, four hundred and fifty feet in length, running between Liverpool and New York, were to be transported, she would require a car not larger than four hundred feet; one rail would therefore have about one hundred and thirty wheels upon it; these wheels would bear six hundred and fifty tons; twelve rails would, therefore, carry seven thousand eight hundred tons. The rails would be placed four feet eight and a half inches apart (standard gauge), and would cover an area fifty feet in width; this multiplied by four hundred feet would give twenty thousand superficial feet of ground to sustain the ship, or, in other words, there would be a pressure of seven hundred and eighty pounds per square foot on the ground. This is less than the weight imposed by a brick wall only one story high; but to further illustrate this he would give them a more familiar example, which all had doubtless frequently observed, viz., that of a horse trotting along a common road in the country. With its rider it imposed a pressure of about twelve hundred pounds upon the road, yet scarcely left the imprint of its shoes upon it. This weight was sustained on an area of about twenty-four square inches, because the entire weight of horse and rider came alternately upon two feet only. The horse's shoes are not more than about twelve square inches each, and thus imposed upon about one-sixth of a square foot a weight of twelve hundred pounds, or nearly ten times the weight per square foot which the heaviest ships would bear upon the roadbed of the ship railway.

It is evident also that if the rails which are used in this country for a first-class railway are sufficient to bear nine tons per wheel of a locomotive running at fifty to sixty miles per hour, they would be amply strong enough to bear a pressure of five tons imposed by the wheels of the ship railway car.

This would give some idea of the great economy with which the permanent way of a ship railway could be constructed in comparison with the cost of digging a canal. Of course, a first-class permanent way would be a necessity, but this being once constructed, its maintenance and repair would be much less than that of a canal across the isthmus, for the simple reason that the rains in Panama are torrential in character, and the amount of detritus washed into the canal would be enormous.

It would not be necessary to keep the rails absolutely true and level, though it would be bad management and neglect to allow an irregularity equal to one inch in their respective levels to occur, but even this would cause no injury to the car, inasmuch as each wheel would be independent of its fellows, and would have one or more strong spiral steel springs over it which would permit it to rise three inches without injury. The entire car would actually be carried upon a mass of steel springs to allow for any inequality in the permanent way.

He had been informed that the ordinary price charged to customers by railways in England for the carriage of coals was a halfpenny per ton per mile; if it were to cost double this to haul loads on the ship railway it would still leave a large margin for profit, and he had been informed only a day or two previously by a shipowner engaged in carrying wheat from California to Liverpool that the current price of freight in San Francisco was then equal to a halfpenny per pound, and that he could well afford to pay one-third of the freight to have his cargoes transported across the isthmus at Tehuantepec, and thus save seven thousand or eight thousand miles which is now required to round Cape Horn.

The weight of the ship is about half that of the total cargo, and the weight of the railway car, on which the ship would be carried, would not exceed one-eighth of the total weight of the ship and cargo, so that there would be about forty per cent. of non-paying load to be hauled, which is considerably less than the proportion of non-paying load on ordinary railways, which is often as much as fifty per cent. and rarely falls below forty per cent.

There is no question about the amount of patronage which a ship railway or a canal would receive from the moment its services were available for general use.

Captain Eads, in addition to the right of building a ship railway, stated that he has also a right to construct and work a railway of standard or narrow gauge to run parallel with the other.

At the close of Captain Eads' remarks, Sir William Armstrong said that there was every reason to believe that the time would come soon when the scheme would be practically carried out, and certainly there was no place on the face of the earth where a ship railway would be of such value and importance as in the position described. He hoped that the interesting and lucid statements made by Captain Eads would elicit discussion from the members of the committee.

Captain Bedford Pim, who has surveyed the Nicaraguan route, and is greatly in favor of a ship canal at that point, had listened to Captain Eads with great interest, but said he must confess that he did not quite go so far as Captain Eads did with the ship railway plan. His idea was to excavate a shallow canal eight feet deep; to raise the ship after the manner described, and to take it through the canal on large pontoons.

Mr. Abernethy observed that, as to the railway, he saw no difficulty in constructing it and in transporting the ships between the two oceans, but he thought the difficulty lay in treating ships with cargoes in them as if they were packing boxes.

Sir F. Bramwell remarked that if ships were able to bear the strain which they underwent in tempestuous seas they would surely be strong enough to bear the strain of crossing the isthmus on the railway. Ships were terribly tossed and roughly handled in heavy waves at sea, and the passengers were generally very happy to get into the railway carriages on shore, and he believed that it would be equally as advantageous to the ships to be relieved on the railway from the severe strains brought upon them by stress of weather at sea.

Captain Eads replied to the remarks made in the discussion and referred to the immense saving in distance to be traversed by the Tehuantepec route when compared with that of Nicaragua. He stated that a canal across the former was not practicable for want of water to supply the series of locks which it would be necessary to construct to carry the ship over the highest elevation; but even if there were abundance of water for the purpose named, the ship railway would nevertheless be the best plan, being cheaper than the canal to construct, and costing less for maintenance; while it would be superior in actual operation.

On the motion of Mr. Bateman, it was resolved to publish Captain Eads' address in the annual Transactions of the Association.

CHEAP GAS FOR GAS MOTORS, ETC.

MR. J. EMERSON DOWSON (London) read a paper before the Mechanical Science Section of the British Association. The author said: In many countries and for many years past, inventors have sought some cheap and easy means of decomposing steam in the presence of incandescent carbon, in order to produce a cheap heating gas; and, working with the same object, the writer has devised an apparatus which has been fitted up in the garden of the Industrial Exhibition, and is there making gas for a 3½-horse power (nominal) "Otto" gas-engine.

The retort or generator consists of a vertical cylindrical iron casing, which incloses a thick lining of ganister to prevent loss of heat and oxidation of the metal; and at the bottom of this cylinder is a grate on which a fire is built up. Under the grate is a closed chamber, and a jet of superheated steam plays into this, and carries with it, by induction, a continuous current of air. The pressure of the steam forces the mixture of steam and air upward through the fire, so that the combustion of the fuel is maintained while a continuous current of steam is decomposed; and in this way the working of the generator is constant, and the gas is produced without fluctuations in quality. The well-known reactions occur, the steam is decomposed, and the oxygen from the steam and air combines with the carbon of the fuel to form carbon dioxide (CO_2), which is reduced to the monoxide (CO) on ascending the fuel column. In this way the resulting gases form a mixture of hydrogen, carbon monoxide, and nitrogen, with a small percentage of carbon dioxide, which usually escapes without reduction. The steam should have a pressure of 1⅛ to 2 atmospheres, and is produced and superheated in a zigzag coil fed with water from a neighboring boiler. The quantity of water required is very small, being only about 7 pints for each 1,000 cubic feet of gas; and, except on the first occasion, when the apparatus is started, the coil is heated by some of the gas drawn from the holder, so that after the gas is lighted under the coil, the superheater requires no attention.

For boiler and furnace work the gas can be used direct from the generator; but where uniformity of pressure is essential—as for gas-engines, gas-burners, etc.—the gas should pass into a holder. The latter somewhat retards the production; but the steam injectors cause gas to be made so rapidly that a holder is easily filled against a back pressure of 1 inch to 1½ inches of water, and at this pressure the generator can pass gas continuously into the holder, while at the same time it is being drawn off for consumption.

The nature of the fuel required depends on the purpose for which the gas is to be used. If for heating boilers, furnaces, etc., coke or any kind of coal may be used; but for gas engines, or any application of the gas requiring great cleanliness and freedom from sulphur and ammonia, it is best to use anthracite, as this does not yield condensable vapors, and is very free from impurities. Good qualities of

this fuel contain over 90 per cent. of carbon, and so little sulphur that, for some purposes, purification is not necessary. For gas-engines, etc., it is, however, better to pass the gas through some hydrated oxide of iron to remove the sulphuretted hydrogen. The oxide can be used over and over again after exposure to the air, and the purifying is thus effected without smell or appreciable expense. Gas made by this process, and with anthracite coal, has no tar and no ammonia; and the small percentage of carbon dioxide present does not sensibly affect the heating power. A further advantage of this gas is that it cannot burn with a smoky flame, and there is no deposition of soot even when the object to be heated is placed over, or in the flame; and this is of importance for the cylinder and valves of a gas-engine.

To produce 1,000 cubic feet only 12 lb. of anthracite are required, allowing 8 to 10 per cent. for impurities and waste. Thus a generator "A" size, which produces 1,000 cubic feet per hour, needs only 12 lb. in that time; and this can be added once an hour, or at longer intervals. No skilled labor is necessary, and in practice it is usual to employ a man who has other work to attend to near the generator, and to pay him a small addition to his usual wages.

The comparative explosive force of coal gas and the Dowson gas, calculated in the usual way, is as 3·4 : 1—*i. e.*, coal gas has 3·4 times more energy than the writer's gas. Messrs. Crossley Bros., of Manchester, the makers of the "Otto" gas-engines, have made several careful trials of this gas with some of their 3½-horse power (nominal) engines; and, in one trial, they took diagrams every half hour for nine consecutive days. These practical trials have shown that, without altering the cylinder of the engine, it is possible to admit enough of the Dowson gas to give the same power as with ordinary coal gas. It has been said that the comparative explosive force of the two gases is as 3·4 : 1; but, as is well known, the combustion of carbon monoxide proceeds at a comparatively slow rate, and for this reason, and because of the diluents present in the cylinder—which affect the weaker gas more than coal gas—experience has shown that it is best to allow five volumes of the Dowson gas for one volume of coal gas, and then the same uniform power is obtained as with the latter.

This gives very important economical results; for if the cost of the Dowson gas (given in the appendix as 4¼d., 3½d., and 2¾d. per 1,000 cubic feet) be multiplied by 5, there will be 1s. 9¼d., 1s. 4½d., and 1s. 1¾d., or a mean of 1s. 5½d. for the equivalent of 1,000 cubic feet of coal gas, which usually costs from 3s. to 4s.; and this represents an actual saving of about 50 to 60 per cent. in working cost. Another practical consideration is that coal gas requires 224 lb. to 250 lb. of coal per 1,000 cubic feet of gas, but the writer requires only 12 lb. per 1,000 cubic feet; and, multiplying this by 5 to give the equivalent of 1,000 cubic feet of coal gas, for engine work, there are 60 lb instead of 224 lb. to 250 lb. This is only 24 to 27 per cent. of the weight of the coal required for coal gas, and in many outlying districts this will effect an appreciable saving in the cost of transport.

APPENDIX.

Table I.

Generator A size (producing 1,000 cubic feet per hour)—	s.	d.	
Anthracite to make gas at the rate of 1,000 cubic feet per hour=12 lb.×9 working hours=108 lb., or say, 1 cwt. at 20s. a ton	1	0	
Allowance for wages of attendant	1	0	
Repairs and depreciation of generator, gasholder, etc. (5 per cent. on £125) =per working day	0	5	
Interest on capital outlay, ditto	0	5	
Total	2	10	
Gas produced	9,000		cub. ft.
Less gas used for generating and superheating steam	1,000		"
Total effective gas for 2s. 10d.	8,000		cub. ft.

Net cost, 4¼d. per 1,000 cubic feet.

Table II.

Generator B size (producing 1,500 cubic feet per hour)—	s.	d.	
Anthracite to make gas at the rate of 1,500 cubic feet per hour=18 lb.×9 working hours=162 lb., or, say, 1½ cwt. at 20s. a ton	1	6	
Allowance for wages of attendant	1	0	
Repairs and depreciation of generator, gasholder, etc. (5 per cent. on £140) =per working day	0	5½	
Interest on capital outlay, ditto	0	5½	
Total	3	5	
Gas produced	13,500		cub. ft.
Less gas used for generating and superheating steam	1,200		"
Total effective gas for 3s. 5d.	12,300		cub. ft.

Net cost 3½d. per 1,000 cubic feet.

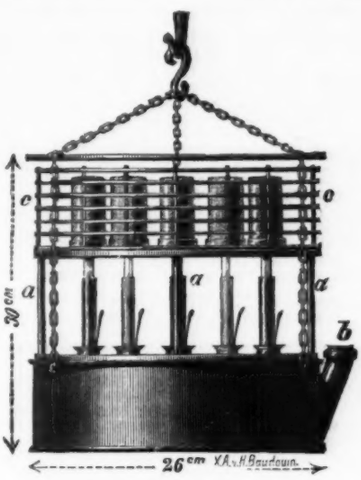
Table III.

Generator C size (producing 2,500 cubic feet per hour)—	s.	d.	
Anthracite to make gas at the rate of 2,500 cubic feet per hour=30 lb.×9 working hours=270 lb. at 20s. a ton	2	4½	
Allowance for wages of attendant	1	6	
Repairs and depreciation of generator, gasholder, etc. (5 per cent. on £160) =per working day	0	6½	
Interest on capital outlay, ditto	0	6½	
Total	4	11½	
Gas produced	22,500		cub. ft.
Less gas used for generating and superheating steam	1,500		"
Total effective gas for 4s. 11½d.	21,000		cub. ft.

Net cost, say, 2¾d. per 1,000 cubic feet.

IMPROVED APPARATUS FOR PREVENTING THE EXPLOSION OF FIRE DAMP.

THE apparatus consists essentially of a kerosene lamp, the burners of which are covered with asbestos caps, which in turn are covered with platinum and palladium. These asbestos caps are heated until they have a bright red color. The apparatus is placed in the mine where the fire damp is expected to accumulate. The caps maintain their bright red heat by means of the kerosene drawn upward by the wicks, but the caps never attain a white heat. All danger of explosions of the gases is thus avoided, for the heat of the caps is not sufficient to ignite the gases, and the latter are gradually consumed on the surfaces of the bright red caps without materially increasing the temperature of the latter. The apparatus consumes from 1,500 to 2,000 cubic yards of fire damp gases per hour. In the accompanying cut, *aa* represents the frame of the apparatus; *b*, opening of the kerosene reservoir; and *c*, the grating or cage for protecting the caps. The apparatus is cheap and very durable. The caps can be heated by means of a blowpipe or similar device.—*Wiener Technologische Blatter.*



IMPROVED APPARATUS FOR PREVENTING THE EXPLOSION OF FIRE DAMP.

HUGUENIN'S FULLING MACHINE.

SEVERAL improvements have been introduced by Mr. Huguenin, of Rheims, into fulling machines, with a view to expedite the operation of fulling, to render the treatment of the fabric better and more efficacious and to prevent its being torn. The improved apparatus is represented in section in the accompanying cut.

The first modification relates to the beaters, *a*, by means of which the fabric is more strongly and regularly worked than it has been heretofore. The two beaters are actuated by two cranks, *b*, and two connecting-rods, *c*. A fly-wheel, *d*, is keyed to one of the extremities of the shaft which carries the cranks, in order to facilitate the backward and forward motion of the beaters. The latter slide in angular guides formed of a metal in which there is as little wear as possible through friction.

To the other end of the shaft which carries the cranks there is fixed a pulley which serves for communicating motion to the connecting-rods. The axle which causes the squeezing cylinders, *x*, to move, carries also a toothed wheel and a pulley with a belt.

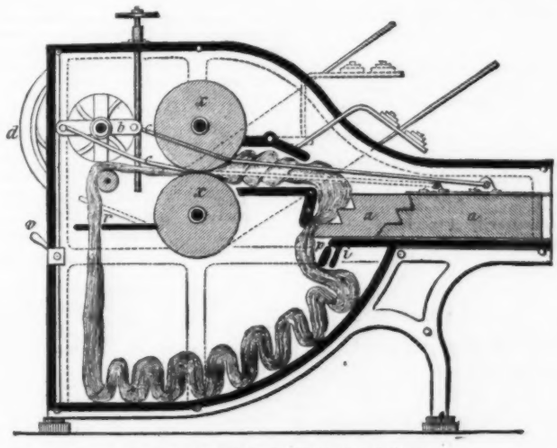
In order that the fabric may be submitted to a greater or less pressure in the machine, as may be required, there is to the right of the machine a shaft which carries a conical wheel having a few teeth on its periphery.

This wheel gears with another one fixed on a shaft which passes transversely across the machine, and which also carries, on either side of the machine, cogwheels that gear with other wheels situated a little above. Behind the cogwheels there is fixed a pulley, gearing with the latter and carrying a belt; and, at their extremities, there are springs by means of which a pressure is exerted upon the upper pressing-plate, *o*. In the interior of the machine, in front of and beneath the beaters, is arranged the lower pressing-plate, *p*, which is driven back or set free by clutches located back of the shaft which traverses the machine. A small ratchet-wheel provided with a click permits of the plates, *o* and *p*, being adjusted in such a way as to stretch the fabric or leave it free, as may be desired. The fabric is prevented from being torn by the following arrangement:

In ordinary fulling machines the fabric passing through the aperture in the hole-board, *r*, being in a floating position, is very easily torn. In Mr. Huguenin's apparatus the hole-board is made movable by means of a support which is capable of being displaced. This support is provided with an appendage and slides upon the side of the machine in a vertical groove, following the motion of the board as soon as the latter is raised by the fabric.

The appendage then carries along a driver, which is fixed behind a shaft on the left side of the machine in such a way that at the moment the collision takes place the shaft is given a rotary motion. This motion, being communicated to a disconnecting clutch resting on the shaft, the belt is instantaneously pushed on to the loose pulley and the machine at once stopped automatically, thus allowing the workman to detach the fabric. A winch, *v*, on the shaft, serves to replace the belt on the fast pulley through the intermedium of the clutch.

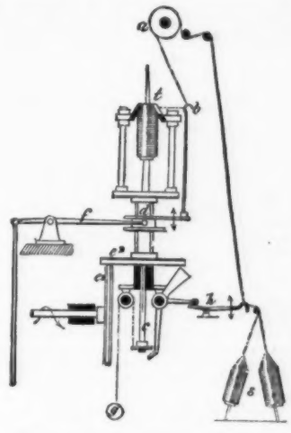
These modifications are applicable to almost all of the existing fulling machines.



HUGUENIN'S FULLING MACHINE.

VOIGT'S WINDING FRAME.

MR. VOIGT, of Chemnitz, first introduced the use of friction disks for actuating the vertical spindles of cone winding frames at the beginning of the year 1878. This system of control, in addition to the easy motion that it effects in the machine, presents also the advantage of rendering possible a quick and certain stoppage of each of the spindles independently in cases where a thread happens to break. Since the above-named date, Mr. Voigt has still been endeavoring to improve on the arrangements of the winding frame in this respect, and the accompanying cut shows a modified apparatus of his invention, which dates from 1879. The spindle in this machine is stationary, and motion is communicated to the pressing cone, an arrangement which constitutes an important difference between this apparatus and all cop machines hitherto constructed. The use of a control by friction permits of applying here, also, a thread-guard or apparatus for preventing the breaking of the thread. Transmission of motion by pressing cone is especially well adapted for weft-doubling machines, inasmuch as it readily allows of a slight twisting of the threads while being carried, thus producing a nearly uniform tension of the isolated threads. When the bobbin is reeled the thread which unwinds turns in the opposite direction, so that the thread which is leaving the shuttle enters the fabric even and uncontorted.



VOIGT'S WINDING FRAME.

The threads coming from the bobbins, *s*, pass over the friction roller, *a*, then through the hook of the guide, *b*, and the slit of the cone, *t*, which lead them to the stationary spindle, *c*. The cone, *t*, which acts as a press-flier, and which determines the form of the wound thread, is invariably connected with the socket, *d*, which surrounds the spindle, *c*, and has an axis in common with it. This cone is given a rotary motion by means of the friction disks, *e* and *e*[a]. The guide, *b*, which participates in the rotary motion, obtains from an eccentric and from the lever, *f*, an alternate ascending and descending motion, the amount of which depends upon the height of the cone, *t*, and which determines the superposition of the layers of thread. The compactness of

the winding is secured by means of a counterpoise, *g*, which presses the spindle, *c*, upward. The circular motion of the guide, *b*, causes a torsion of the portion of the thread stretched between this piece and the friction roller, *a*. Between the latter and the bobbins, *s*, each thread passes into the aperture of a small lever, *h*, which, whenever a thread breaks, falls and acts upon a three-armed lever, *i*, in such a manner that the latter raises the disk, c^3; and the latter then being no longer in contact with c^3, the corresponding cone, *t*, ceases to move. The lever, *i*, acts precisely in the same way, without the breaking of a thread, when the bobbin has reached the size desired; the extremity of the spindle, *c*, lowering, acts upon the lower arm of the lever, *i*, and raises the disk, c^3.

ON SOME PROBLEMS ARISING IN THE ASSAY OFFICE.

By C. H. AARON.

TO FIND THE WEIGHT OF GOLD IN A SPECIMEN OF GOLD IN QUARTZ, ETC.

THE rules for this operation, as given in most books, involve a great deal of work, and are such as no one but a Chinaman can venture to trust his memory with. I have therefore tried to find a method which, if not simpler, will at least involve the use of fewer figures and be more easily remembered. Of the following nine rules, some appear to fulfill these conditions.

Rule 1.—From the product of the specific gravity of the specimen multiplied by the specific gravity of the gold, subtract the product of the specific gravity of the quartz multiplied by the specific gravity of the gold. The remainder divide by the difference between the specific gravity of the gold and that of the quartz. The result will be the parts of gold in as many parts of the specimen as equal the specific gravity of the specimen. Example: A specimen weighs 32 oz., its specific gravity is 8. Taking the specific gravity of gold equals 19, and that of quartz equals 2·6, then

$$\begin{array}{l} 8 \times 19 = 152 \\ 2{\cdot}6 \times 19 = \underline{49{\cdot}4} \end{array}$$

$$19 - 2{\cdot}6 = 16{\cdot}4 \mid 102{\cdot}6 \mid = 6{\cdot}256 \text{ oz.}$$

of gold in 8 oz. of the specimen, and 8 : 6·256 :: 32 : 25·024 oz. of gold in the specimen. In this case, as $8 = \frac{1}{4}$ of 32, it is only necessary to multiply 6·256 by 4. Assuming the specific gravity of gold and gangue as above, the rule may be stated thus: Multiply specific gravity of specimen by 19; subtract 49·4, and divide the remainder by 16·4. The quotient is the number of parts of gold in as many parts of the specimen as equal specific gravity of specimen. The constants can be altered to suit any given specific gravity of metal and of gangue, and a note of them kept at hand ready for use.

Rule 2.—From the product of specific gravity of specimen into specific gravity of gold, subtract the product of specific gravity of specimen into specific gravity of quartz for a divisor, and from the same subtract the product of specific gravity of quartz into specific gravity of gold for a dividend. Divide, and multiply the quotient by the weight of the specimen. The product will be the weight of the gold in the specimen.

Example, same as before:

$$\begin{array}{l} 8 \times 19 = 152 \\ 8 \times \ 2{\cdot}6 = \ 20{\cdot}8 \\ \hline 131{\cdot}2 \end{array} \qquad \begin{array}{r} 152 \\ 19 \times 2{\cdot}6 = 49{\cdot}4 \\ \hline 102{\cdot}6 \end{array}$$

Divisor, 131·2; Dividend, 102·6; Quotient, 0·782, which, multiplied by 32=25·02 oz. of gold in the specimen.

Rule 3.—Subtract specific gravity of specimen from specific gravity of gold; the remainder call volume ratio of quartz. Substract specific gravity of quartz from specific gravity of specimen; the remainder call volume ratio of gold. Multiply volume ratio of quartz by specific gravity of quartz, the product is the weight ratio of the quartz; multiply volume ratio of gold by specific gravity of gold, the product is the weight ratio of the gold. The sum of these is the corresponding weight ratio of the specimen.

Divide the actual weight of the specimen, by proportion, in the ratio found.

Example, the same.

$$\begin{array}{rcrcl} 19 & - & 8 & = 11 & = \text{volume ratio quartz.} \\ 8 & - & 2{\cdot}6 & = 5{\cdot}4 & = \text{“ “ gold.} \\ 11 & \times & 2{\cdot}6 & = 28{\cdot}6 & = \text{weight ratio quartz.} \\ 5{\cdot}4 & \times & 19 & = 102{\cdot}6 & = \text{“ “ gold.} \\ 102{\cdot}6 & + & 28{\cdot}6 & = 131{\cdot}2 & = \text{“ “ specimen,} \end{array}$$

and 131·2 : 102·6 :: 32 : 25·024 oz. of gold in the specimen.

Rule 4.—From specific gravity of gold × specific gravity of specimen subtract specific gravity of gold × specific gravity of quartz, and from the latter subtract specific gravity of quartz × specific gravity of specimen. The first remainder is the ratio weight of gold; the second is the ratio weight of quartz.

Example, the same:

$$\begin{array}{l} 19 \times 8 = 152 \\ 19 \times 2{\cdot}6 = \ 49{\cdot}4 \\ \hline \text{Ratio of gold, } 102{\cdot}6 \end{array} \qquad \begin{array}{r} 49{\cdot}4 \\ 2{\cdot}6 \times 8 = 20{\cdot}8 \\ \hline \text{Ratio of quartz, } 28{\cdot}6 \end{array}$$

The rest of the calculation is the same as in rule third.

The rule may be more easily remembered if stated thus: Proceed as in reducing to a common denominator the fractions representing the displacement of the substances in water, namely: $\frac{1}{19}$, $\frac{2{\cdot}6}{8}$, $\frac{1}{8}$, so far as to obtain the new numerators, the common denominator not being required; then, from the greatest numerator subtract the next less, and from that the least. The first remainder is the ratio weight of the gold; the second that of the quartz. In this example the new numerators are: $\frac{20{\cdot}8}{\ldots}$, $\frac{152}{\ldots}$, and $\frac{49{\cdot}4}{\ldots}$, as found above.

Rule 5.—Divide any number by the specific gravity of the gold, the quartz, and the specimen respectively. From the greater quotient subtract the next less, and from that the least. The first remainder is the ratio weight of the gold in the specimen. The second is that of the quartz. Any number will do for a dividend, but the most convenient is the specific gravity of the gold, giving 1 for the least quotient.

Example, the same:

$$\begin{array}{rcl} 19 \div 19 & = & 1 \\ 19 \div 2{\cdot}6 & = & 7{\cdot}3 \\ 19 \div 8 & = & 2{\cdot}37 \end{array} \quad \left| \quad \begin{array}{l} 7{\cdot}3 - 2{\cdot}37 = 4{\cdot}93 = \text{ratio of gold.} \\ 2{\cdot}37 - 1 \ = 1{\cdot}37 = \text{“ quartz.} \\ \hline 6{\cdot}30 = \text{“ specimen.} \end{array} \right.$$

then 6·30 : 4·93 :: 32 : 25·03 oz. of gold in the specimen; the slight discrepancy in this result, as compared with the others, is owing to not carrying the division of 19 to more decimal places.

Rule 6.—Multiply specific gravity of specimen by the difference between specific gravity of gold and specific gravity of quartz. Also multiply specific gravity of gold by the difference between specific gravity of specimen and specific gravity of quartz. Divide the last product by the first, and multiply by the weight of the specimen. The result is the weight of gold in the specimen. Taking the same example:

$$\begin{array}{rcrcl} 19 & - & 2{\cdot}6 & = & 16{\cdot}4 \\ 16{\cdot}4 & \times & 8 & = & 131{\cdot}2 \\ 102{\cdot}6 & + & 131{\cdot}2 & = & 0{\cdot}782 \end{array} \quad \left| \quad \begin{array}{rcrcl} 8 & - & 2{\cdot}6 & = & 5{\cdot}4 \\ 5{\cdot}4 & \times & 19 & = & 102{\cdot}6 \end{array} \right.$$

$$0{\cdot}782 \times 32 = 25{\cdot}02 \text{ oz. of gold in the specimen.}$$

As, in any case, the specimen must be weighed in air and in water, and as the specific gravity of the metal and the gangue may vary considerably in different specimens, some labor may be saved, and the weight of any metal or other substance in any gangue found by proceeding as follows:

Rule 7.—Weigh the specimen, a portion of the metal, and a portion of the gangue, each in air and in water. Divide the difference between the respective weights in air and in water by the weights in air. From the greater quotient subtract the next less, and from the latter the least. The first remainder is the weight ratio of the heavier substance, the second is that of the lighter. Example: A specimen of native silver in calc spar weighs 84 lb. avoirdupois in air, and 73·5 lb. in water. A piece of the silver weighs 27 (ounces, grains, or anything) in air, and 24 in water. A piece of the spar weighs 20 in air and 12 in water; then,

$$\begin{array}{lr} \text{Spar in air} \ldots & 20 \\ \text{Spar in water} \ldots & 12 \\ \hline \text{Dif.} & 8 \quad +20 = 0{\cdot}400 \\ \text{Specimen in air} \ldots & 84 \\ \text{Specimen in water} \ldots & 73{\cdot}5 \\ \hline \text{Dif.} & 10{\cdot}5 + 84 = 0{\cdot}125 \\ \text{Silver in air} \ldots & 27 \\ \text{Silver in water} \ldots & 24 \\ \hline \text{Dif.} & 3 \quad +27 = 0{\cdot}111, \text{ and} \end{array}$$

$$\begin{array}{l} 400 - 125 = 275 = \text{proportion of silver.} \\ 125 - 111 = \ 14 = \text{proportion of spar.} \\ \hline 289 \quad \text{proportion of specimen.} \end{array}$$

289 : 275 :: 84 : 79·93 lb. of silver in specimens, and 79·93 × 14·583 = 1,165·62 oz. troy.

When a body is weighed in air and in water, the weight in air divided by the difference is the specific gravity; the difference divided by the weight is the *specific displacement*. The specific gravity represents the relative weights of equal volumes of the substance and of water, when that of the water is called 1. The specific displacement represents the relative weights of equal volumes of the same when the weight of the substance is called 1. The specific displacement is the reciprocal of the specific gravity.

The fundamental equation of our problem is generally given as $\frac{x}{a} + \frac{y}{b} = \frac{d}{c}$ in which *x*, *y*, and *d* are the respective weights of gold, quartz, and specimen, and *a*, *b*, *c*, are the specific gravities. This means that the water displaced by the gold, plus that displaced by the quartz, is equal to that displaced by the specimen, whence specific displacement of *x* plus specific displacement of *y* equal specific displacement of specimen.

Now specific gravity of gold minus specific gravity of specimen, and specific gravity of specimen minus specific gravity of quartz, are the relative *volumes* of gold and quartz, from which the relative weights can be deduced; but specific displacement of quartz minus specific displacement of specimen, and specific displacement of specimen minus specific displacement of gold, are the relative *weights* at once; and if the substances are weighed in air and in water, it is as easy to find the specific displacement as the specific gravity. Hence Rule 7th. The specific displacement of any substance heavier than water is always less than unity; consequently, when all of the substances are heavier than water, the decimal point may be disregarded in that rule.

Or more readily:

$$\begin{array}{l} 0{\cdot}0526x + 0{\cdot}3846y = 4 \\ 0{\cdot}0526x + 0{\cdot}0526y = 1{\cdot}082 \\ \hline 0{\cdot}3330y = 2{\cdot}318 \end{array}$$

And $2{\cdot}318 \div 0{\cdot}332 = 6{\cdot}98$ oz. quartz.

$$\begin{array}{lll} \text{Then} & 0{\cdot}3846x + 0{\cdot}3846y = 12{\cdot}307 \\ \text{And} & 0{\cdot}0526x + 0{\cdot}3846y = \ 4{\cdot}000 \\ \hline & 0{\cdot}3320x = \ 8{\cdot}307 \end{array}$$

And $8{\cdot}307 \div 0{\cdot}332 = 25{\cdot}02$ oz. gold.

If the specific displacement of the gold or of the quartz be not determined experimentally, either can be got by dividing 1 by the assumed specific gravity. Thus, in the example of the silver specimen, the specific gravity of the spar is 20÷8=2·5; the specific displacement is 8÷20=0·4; which is the same as 1÷2·5; hence, when the specific gravity of each component and of the specimen is given, the corresponding specific displacement for each may be found by dividing 1 by each specific gravity; but the *proportional* specific displacement can be got by dividing *any* number by each specific gravity; hence Rule 5th.

Again:

Let *x*=weight of heavier substance, *a* its s. d.
y= “ lighter “ *b* its s. d.
c= “ specimen, *d* its t. d.,
or total displacement=difference of weight in air and water.

$$\begin{array}{ll} \text{Then} & x + y = c \\ \text{And} & ax + by = d \end{array}$$

Whence I deduce the following:

Rule 8.—From the product of weight of specimen into specific displacement of lighter substance, subtract total displacement of specimen. From total displacement of specimen subtract the product of weight of specimen into specific displacement of heavier substance. Divide each remainder by the difference between specific displacement of lighter and specific displacement of heavier substance. The first quotient is the weight of the heavier, the second of the lighter substance in the specimen.

Taking our first example:

Specific displacement of quartz equal 0·3846; specific displacement of gold equal 0·0526; total displacement of specimen equal 4; weight equal 32.

$$\begin{array}{rcrcl} & & 0{\cdot}3846 \times 32 & = & 12{\cdot}307 \\ & & 12{\cdot}307 \ - \ 4 & = & 8{\cdot}307 \text{ first remainder} \\ & & 8{\cdot}307 \ + \ 0{\cdot}332 & = & 25{\cdot}02 \text{ oz. gold.} \\ \text{And} & & 4 \ - \ 1{\cdot}683 & = & 2{\cdot}317 \text{ second remainder.} \\ & & 2{\cdot}317 \ + \ 0{\cdot}332 & = & 6{\cdot}98 \text{ oz. quartz.} \end{array}$$

And again, if the specific gravity of the component be given, or assumed, it is not necessary to change anything, nor to obtain specific gravity of the specimen; for, let specific gravity of gold=*a*; specific gravity of quartz=*b*; weight of specimen=*c*; and its difference of weight in air and water=*d*; and let *x*=weight of gold, and *y*=weight of quartz in the specimen. Then,

$$x = (ac - abd) \div a - b, \text{ and}$$
$$y = (abd - bc) \div a - b, \text{ whence}$$

Rule 9.—Weigh the specimen in air and in water, and note the difference.

From the product of specific gravity of gold multiplied by weight of specimen in air, subtract the product of specific gravity of gold, multiplied by specific gravity of quartz, multiplied by difference of weight of specimen in air and water. The remainder, divided by the difference between specific gravity of gold and specific gravity of quartz, is the weight of gold.

From the subtrahend above subtract the product of specific gravity of quartz, multiplied by weight of specimen in air. The remainder, divided by the above divisor, is the weight of the quartz.

Taking our first example again

$$\begin{array}{l} 19 \ \times 32 = 608 \\ 19 \times \ 2{\cdot}6 \times \ 4 = 197{\cdot}6 \\ \hline 19 - 2{\cdot}6 = 16{\cdot}4 \mid 410{\cdot}4 \mid 25{\cdot}0244 \text{ oz. of gold.} \end{array}$$

$$\begin{array}{l} \text{And} \qquad 197{\cdot}6 \\ 2{\cdot}6 \times 32 = \ 83{\cdot}2 \\ \hline 16{\cdot}4 \mid 114{\cdot}4 \mid 6{\cdot}9756 \text{ oz. of quartz.} \end{array}$$

This rule is easy to work and saves labor. It is, however, less easy to remember than some of the preceding.

When accuracy is desired, as in buying gold specimens with gangue, it is quite important that the *relative* specific gravities, or the displacement, should be obtained, and as it is only necessary that they should be correct relatively, any liquid at any temperance will answer for the determination.

In the first example, reckoning the gold at $20 per oz., the value is $500.40. Had the specific gravity of the specimen been taken as 8·1, the value would have been $502.80. With 8·2 as the specific gravity it is $506.60, and with 9 it is $520 approximately.

An error in the specific gravity of the gold is not compensated by the greater quantity found. In the example referred to, 18·5 specific gravity would give 25·17 oz. of gold in the specimen, but the value would be only about $488.

TO MIX ACID AND WATER, OR STRONG AND WEAK ACIDS, TO ANY STRENGTH BELOW THE MAXIMUM.

Rule.—From the density, by Baume's hydrometer, or specific gravity of the stronger acid, subtract the required density, or specific gravity; the remainder equals the required proportional volume of the weaker acid or water. From the required density or specific gravity, subtract the density or specific gravity of the weaker acid or water, the remainder equals the required volume of strong acid. Measure in the proportion thus found, and mix.

Example.—It is required to dilute nitric acid of 54° B. to 32° B.

$$\begin{array}{l} 54 - 32 = 22 = \text{proportional volume of water.} \\ 32 - 0 \ = 32 = \text{“ “ “ acid.} \end{array}$$

Again.—Required to mix acid of 53° B. with acid of 28° B. to make acid of 32° B.

$$\begin{array}{l} 53 - 32 = 21 \text{ volumes of stroug acid.} \\ 32 - 21 = 11 \quad \text{“ “ weak “} \end{array}$$

The rule will not apply to the dilution of sulphuric acid, because the density of a mixture of sulphuric acid and water is above the mean. I have, however, found it serviceable in preparing nitric acid for parting.

TO CONVERT DEGREES BAUME INTO SPECIFIC GRAVITY.

Divide 145 by 145 minus the number of degrees Baume; the quotient is the specific gravity.

Example:

I have nitric acid of 47° Baume, what is its specific gravity?

145—47=98 and 145÷98=1·48 specific gravity.

TO CONVERT SPECIFIC GRAVITY INTO DEGREES BAUME.

Divide 145 by specific gravity, and subtract the quotient from 145; the remainder is the number of degrees Baume corresponding to specific gravity.

Example:

I have sulphuric acid of 1·71 specific gravity, that is how many degrees Baume?

145÷1·71=84·8 and 145—84·8=60° Baume.

I have taken this rule from an article in the *Chemical News*, in which the matter is thoroughly discussed. It appears that there is a good deal of disagreement between various Baume hydrometers, and Baume died without leaving any rules regarding them. Hence the results of the above rule do not quite agree with those of some authorities.

It may seem superfluous to give rules for so simple an operation as the rectification of the normal solution of salt used in the humid assay of silver bullion, yet I have seen students a good deal puzzled over it, and so I venture to offer the following simple rule without explanation:

1. If the solution is too weak, that is, if it gives too high a result in an assay of test silver:

Multiply the whole quantity of salt which was used in making the solution, by the number of points that the test assay is too high, and divide by 1,000. The quotient is the quantity of salt required to be added to the normal solution.

Example: The solution was made with 650 grains of salt. A test assay gives the fineness of pure silver as 0·1007, or 7 points too high; then 650 × 7=4,550, which, divided by 1,000, gives 4·55 grains of salt required to be added to the solution to make it standard.

When dry salt is used in making the rectification, it should not be put at once into the large vessel containing the solution, but should be first dissolved in a smaller vessel, using not water, but some of the normal solution for the purpose. The dish or beaker used may afterwards be washed with a very little water, and the washings added to the solution. The small quantity of water thus added will tend to correct a slight error which might otherwise arise from the fact that a little of the original solution was consumed in making the test assay.

The rule applies equally to the saturated solution of salt used by some assayers for making the normal solution. It may not be mathematically accurate in all cases; that depends upon the cause of the discrepancy, as whether it arises from incorrect measurement of the water in making the solution, or from error in weighing the salt, or from impurity of the salt, but it is practically correct.

2d. If the solution is too strong, that is, if it gives the result of a test assay too low. Multiply the whole quantity of water which was used or intended to be used in making the solution, by the number of points that the test assay is too low, and divide by 1,000. The quotient is the quantity of water to be added to the normal solution. A correction for the percentage of solution consumed in the test may be made, but it is not worth while, unless only a very small quantity has been prepared. As the discrepancy in this case is almost certain to have been caused by erroneous measurement of the water, the rule may be considered rigidly correct.

TO CONVERT DEGREES OF FAHRENHEIT'S THERMOMETER INTO DEGREES CENTIGRADE.

The zero of Fahrenheit is the temperature of snow and salt, which was once supposed to be the lowest possible. The zero of Centigrade is the freezing point of water, or 32° Fahrenheit. Hence, all temperatures above 32° Fahrenheit are plus, or above zero Centigrade; and all below 32° Fahr. are minus, or below zero Centigrade. From the freezing point to the boiling point is 180° on the Fahrenheit scale; on the Centigrade it is 100°. Now, 100 is $\frac{5}{9}$ of 180; hence, to convert degrees F. into the corresponding degrees C., we must multiply by 5, and divide by 9. Zero C. being 32° F., we must observe the following rules:

For temperatures above 32°, subtract 32, multiply the remainder by 5, and divide by 9. The quotient is plus Centigrade. For temperatures below 32°, subtract the number of degrees from 32, multiply by 5, and divide by 9; the result is minus C. For temperatures below zero F., add 32, multiply by 5, and divide by 9; the quotient is minus C. To state it briefly:

Multiply degrees above or below 32 by 5, and divide by 9, remembering that if the degree Fahrenheit is above 32, the corresponding degree Centigrade is +, but if below, —.

Example.—Convert 45° F. into C.; 45—32=13 and 13×5=65, then 65÷9=7·22° C.

As 45 is more than 32 it is plus, although the sign need not be prefixed, being understood. But, convert 28° F. into C.; 32 —28=4, and 4×5÷9=2·22, and because 28 is less than 32, the sign is —2·22° C. Convert —17° F. into C.; 17+32=49, and 49×5÷9=—27·22° C.

TO CONVERT DEGREES CENTIGRADE INTO DEGREES FAHRENHEIT.

If above zero, multiply by 9, divide by 5, and add 32. The sign is +.

Example: Convert 24° C. into F.

24×9=216, and 216÷5=43·2, and 43·2+32=75·2° F.

If below zoro, multiply by 9, and divide by 5, and if the result is more than 32, subtract 32, and the sign is minus; but if less, subtract from 32, and prefix the plus sign.

Example: Convert —52° C. into F.

52×9=468, and 468÷5=93·6; then, as it is more than 32, subtract that number, and —93·6 —32= —61·6° F.

Again: Convert —6° C. into F. 6×9=54, and 54÷5= 10·8, which, being less than 32, must be subtracted therefrom, leaving 21·2° Fahrenheit, which is plus.—*Min. and Sci. Press.*

ON THE HEAT GENERATED IN A MAGNET WHEN IT IS MAGNETIZED AND DEMAGNETIZED.

By HENRY A. ROWLAND, Professor of Physics in the Johns Hopkins University, Baltimore, Md.

WHEN first, as a student of physics, I read that the mechanical energy of a cannon ball became transformed into heat when the ball struck the target, I remember wondering whether the heat was generated in the ball or in the target, and what would happen were the ball and target so hard that there should be no penetration of the ball into the target or any distortion of the ball. I remember that it required considerable thought for me to finally see that the heat was only generated in the softer body, and that when no distortion of shape took place no heat could be generated. But it was finally clear that the generation of heat took place in the ball or the target, according as one or the other was the softer.

A raised weight represents stored energy, but if we let the weight fall the heat equivalent of the energy does not necessarily appear in the weight, but may be generated entirely in other bodies and none in the weight. Just so a magnetized bar of iron represents a store of energy, and we often hear it stated that when such a bar is demagnetized the equivalent of the energy goes to heating the bar. So little has this subject been understood that some physicists have even gone so far as to investigate this generation of heat, thus supposing that they were investigating a subject whose laws were unknown.

My attention was first drawn to this subject by the description of an experiment made by Edison, and which was made when investigating, in a series of remarkable experiments, the losses of energy in a dynamo-electric machine. He there showed that a cylinder composed of sheets of iron separated by paper was scarcely heated perceptibly when revolving in a strong magnetic field, although the whole mass had its magnetism reversed twice every revolution. This proved distinctly that heat does not necessarily accompany magnetization and demagnetization, but is almost solely the result of the electric currents induced in the revolving mass by the change of magnetization. And so, when the observers above referred to were experimenting on the heat produced by rapid magnetization and demagnetization, they were merely observing the heat produced by induced currents in the body of the magnet.

The theory of the subject is perfectly simple. The raised weight or the magnetized bar both represent a store of potential energy, but when that energy takes the form of heat it does not necessarily appear in the weight or in the magnet, but may appear in some other body. The weight falls on a soft body, and the heat is generated in it. The magnet may be incapable of having currents generated in it, and in that case the heat appears in a neighboring conductor, and not in the magnet. Consider a piece of soft iron subjected to the magnetizing force of an electric current in a helix around it. There is energy stored up in the magnetized iron. Stop the current, and what has become of the energy? Part has evidently appeared as the extra current, but part also goes to generating currents in the iron itself, and thus to heating it. Now place a copper tube around the iron, and we shall observe that there is a new distribution of energy. The extra current is now weaker, and the iron is not heated so much, but the energy now appears as a current in the copper tube, and finally goes to heating it. Now divide up the iron in such a manner that no currents can be generated in it, and it is evident that less heat will be generated in it, nearly or quite the whole energy of magnetization being expended in heating the copper tube and in producing the extra current in the primary wire.

I do not mean to here affirm that no heat can be due to the demagnetization alone, but that we have at present no experimental proof of such direct transformation. All the experiments hitherto made have merely given us the heating due to induced currents.

The importance of this principle in dynamo-electric machines is apparent, for although many have guarded against the generation of currents, yet I believe it is to Edison that we owe the experiment which first forcibly illustrated the fact that energy is *not necessarily* lost when a mass of iron is magnetized and demagnetized, but that any loss of energy can only arise from induced currents.

Paris, September 16, 1881.

THE EYES OF SCIENCE.

IN a communication to the New York *Herald*, describing the wonders of the eyes which science has fashioned—telescopic, microscopic, spectroscopic, and, most marvelous of all, photographic eyes—Mr. Richard H. Proctor says:

Ordinary human eyesight, even when strengthened and extended by optical devices, possesses certain imperfections and is used under certain difficulties. For instance, at least a tenth of a second is required for the eye to take a full look at any object. Even if the eye could see an object in less time the image remains at least this time impressed on the retina. Thus the eye cannot see an object which moves very rapidly, and even when an eye sees an object moving not too rapidly, or moving in a circle so as continually to renew the impression (as where a burning rod is whirled round in a dark room), the object is not seen as it really is, but the successive images, owing to the persistence of luminous impressions, are blurred together into an image utterly unlike the real object. Again, when an object is rapidly changing in shape the eye is often quite unable to see distinctly any one of the shapes which the object assumes. Thus scarcely one of the attitudes of a galloping horse can be seen by the human eye, insomuch that the finest pictures of a charge or a race show not one attitude which a horse really assumes when galloping. Yet again, the eye is often prevented from recognizing the true shape of an object which is itself at rest, by reason of continual fluctuations in the medium through which the object is seen, as for instance when the telescopic image of a sun spot is examined through disturbed air, or when smaller details of the solar surface are examined through the air at its very stillest.

In all cases the real trouble is that the eye requires a certain definite though short time in which to take in, as it were, the visual image, and that during this time the object forming the image is changing in form, either actually or apparently. On the other hand, there are cases of an opposite kind, in which the eye fails to recognize objects or their details because of their exceeding faintness, the eye gaining nothing by the length of time during which it is in action. Thus if we look at a point in the heavens at night where there is a telescopic star the eye fails to see that orb if directed toward it during the tenth of a second (the period necessary for distinct vision under ordinary conditions), nor can the eye see the orb better if directed toward it for a second or for a minute or for an hour. Now science possesses an eye free from these defects, by means of which ordinary vision may be made to see an object as it would be seen if the human eye could take in the image in the thousandth part of a second, or even less time, or, on the other hand, as it might be seen if the human eye could look steadily for an hour or more, gaining distinctness of vision precisely in proportion to the increase of the time during which the eye was used.

For instance, in lecturing on the sun I have been able to tell my hearers that a certain photograph of the sun's surface had been so rapidly taken as to show details which no astronomer had ever actually seen or could see, even though he used the most powerful telescope ever made, and gave to the study of the sun with such an instrument every moment of his working life.

On the other hand, but a few weeks ago I was looking in Dr. Henry Draper's observatory at a picture of the great nebula in Orion which had been two hours and twenty minutes forming itself on the retina of the photographic eye of science—in other words, the negative had required an exposure of this duration. I say nothing, though I might well say much, on the mechanical skill and ingenuity required to retain the telescopic image so long unchanged in position, though all the time the diurnal motion of the heavens was carrying Orion round the heavens at the rate (in reality a slightly greater rate) at which the sun moves in the skies, nor do I dwell on the optical and physical difficulties involved in the task which Dr. Draper had thus successfully achieved. The point I wish chiefly to dwell upon is this, that where such a photograph is taken, science does in reality employ an eye which can give hours to a single look. And let it be noted that we see now but the beginning of the use of the photographic eye, which can see in the five-thousandth part of a second if need be, or if need be can rest its gaze for many hours on the same object, seeing more and more as minute after minute passes on. Yet already the swifter view of the photographic eye has shown details which the unaided human eye, or that eye aided only by the telescope or microscope, could never see, while the steadfast gaze of the photographic eye has revealed what it has been given to no human eye to see by direct vision.

Note, further, that the photographic eye in seeing, delineates also, whereas often enough the eye keenest to see is but little skilled to guide the hand to delineate what is seen, and yet oftener the ordinary eye can obtain but so brief a view of an object that there is no time to draw what is seen without trusting to memory, which in such matters is too often treacherous. The finest picture of the solar rice grains as drawn by any human artist has much less value than have Janssen's instantaneous photographs of the sun's surface. The best picture of the great Orion nebula—which, despite Mr. Delarue's opinion in favor of the view taken with Lord Rosse's telescope, I consider to be unquestionably Mr. Trouvelot's picture taken with the great Washington telescope—shows no details which are not clearly recognizable in Dr. Draper's beautiful negative, while skillful though Mr. Trouvelot is as an artist, nature has surpassed him in presenting truthfully not only all details but all grades and varieties of shading. And these are but illustrative instances, belonging to the beginning of the application of photography to science.

HOW CATTLE ARE SHIPPED AT EAST BOSTON.

THE business of shipping cattle to Europe is comparatively a new enterprise, and, although large numbers are shipped weekly from many of the large Atlantic ports, and they have become a regular cargo for some of the transatlantic lines of steamships, the business may still be said to be in its infancy. The steamship lines, seeing that this trade must soon become one of considerable importance, have not been slow to take advantage of it, by the facilities accorded the shippers, and by the fitting up and building of vessels specially adapted to their wants.

From New York probably the larger number of cattle are shipped, but Boston is not far behind in this regard; for, being one day's sailing nearer Queenstown, with most ample dock facilities, through transportation by the Albany and Hoosac Tunnel routes from the Prairie States, she must, in time, do a good share of this trade. It is not without considerable risk to a steamer leaving port loaded with cattle, that they may arrive safely on the other side, for stormy and tempestuous weather may be encountered, and those under deck, by the necessary closing of the hatches, become suffocated, while the deck load may be washed and thrown about by the waves. Fresh water must either be carried or distilled from the sea, and be supplied in liberal quantities. A lack of any of these essential points is enough to cause terrible suffering among the animals, whose arrival in an emaciated and feverish condition will necessarily be at a loss to their owner, while, if, landed safely and in a prime condition, they can be put upon the English market, furnishing a dainty morsel of roast beef to tickle the palate of John Bull, the enterprise is attended with a good profit.

The steamship Canopus took out 414 head from Boston, Sept. 28th, and the manner and scenes incident to the loading were quite interesting. The steamship is one of the smaller of the Warren Line, and in arrangements, which were only temporary and roughly built, not like the steamer Missouri, capable of carrying 1,021 cattle, or some others of the line, which are newer boats and built with an especial adaptation for the cattle trade; but still the steamer was large enough to give a good idea of how the business is conducted.

The stalls were built in rows on both sides of the vessel, and seemed quite roomy and comfortable, 160 cubic feet space being allowed to each bullock. The cars are now run into the long shed, and the first process in the operation begun. Strong, wiry young fellows enter through a trap door on the tops of the cars, and, scrambling about on the backs of the cattle, place a rope around the horns of each, leaving an end of five or six feet. This end of the rope is to tie the animals when they reach the deck, and is easier put on now than afterwards. The operation is attended with considerable risk, as the man must do his work quickly, and guard against horns, a kick, or a too sudden thrown upward, against the top of the car. Then all the doors of the shed are closed with the exception of one at the end, leading to a slatted gangway, over which the cattle are driven. Now, "All ready," shouts the "Boss," and the doors of the cars are thrown open, one at a time, but in quick succession, and the cattle come leaping out. At this point comes a small army of men and boys, armed with sticks, knotted ropes, or whatever they can lay their hands on, and with a great noise start the animals through the door and over the gangway. That large white steer that comes out with a jump and a snort is just from the prairies of Illinois; there is mischief brewing in his eye; he don't intend to give up his liberty without a struggle. He tries to break through the men and boys, but they are ready for him, and with a blow from a knotted rope, send him back among his companions, who, by force of numbers, carry him along through the passage way. Now he jumps again, bellows, rides his companions, blocks up the way, and has his tail twisted by one of the men, in consequence; but over this proceeding is the watchful eye of an agent of the Society for the Prevention of Cruelty to Animals, who, if it is carried too far, says, with a word of authority, "Stop." When, after much trouble, he finally gets on deck and to his stall, which he shares with another equally wild, he is made fast by the rope, given a bed, fed, watered, and begins a voyage of nearly three thousand miles.

The steamship had, also, 538 sheep, and they are loaded in about the same manner as the cattle, although with less difficulty, as it is only necessary to lead in a "leader," and the rest will follow. Sheep are allowed 20 cubic feet of space, and fed hay, corn, and shorts. Frank Howard, of Columbus, Ohio, the owner of the sheep, and who goes with them, told a *Farmer* reporter that he did not expect to get them all safely to port, but should he get some less than 500 of them over, and find a good market, he would be satisfied with the trip. This is about the case with the cattle; losses are expected, and arrangements made accordingly, but at this season, a pleasant voyage is anticipated, and a cargo of good American beef to put on the English market, almost counted on.

Shippers say that, owing to the large quantities of Scotch and Irish beef now going on the English market, American importations allow but a small profit; but this is in a great measure offset by the low freight rates of the steamers, that, only about a year ago, were charging £4 per head, but now take them for about £1. The owners of the cattle were Lingham & O'Brien, 337 head, and Hathaway & Jackson, 75.—*N. E. Farmer.*

PNEUMATIC CLOCKS.

IN our illustrated article on this subject published in the SUPPLEMENT of August 13, 1881, the credit of originating the system should have been given to Charles Mayrhofer, of Vienna. Our readers will doubtless remember that in a previous number of the SUPPLEMENT we gave an account of Mr. Mayrhofer's successes, to which (SUPPLEMENT number 84) we now refer for a correct history of the method.

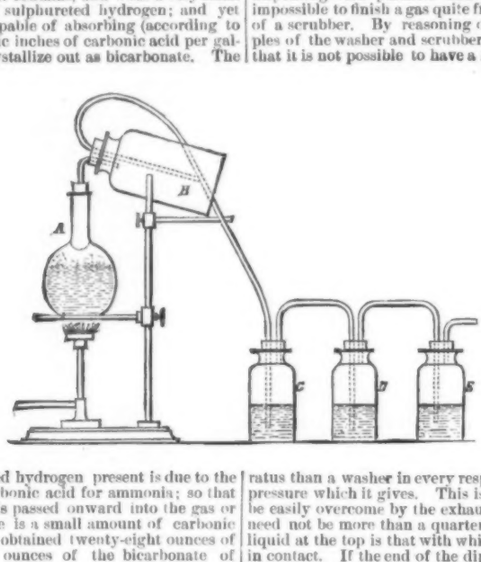
NEW PROCESSES OF GAS PURIFICATION, BASED ON THE DIRECT UTILIZATION OF ITS IMPURITIES IN THE PRODUCTION OF COMMERCIAL SALTS.

AT a recent meeting of the North British Association of Gas Managers, Mr. G. Valentine, F.C S., of Arbroath, read the following paper :

As the experiment I am about to perform takes some time, I will start it first, by lighting the gas, so that it may be proceeding while I am reading the paper.

At the same time I may as well give a brief explanation of what is going on here. In flask A is some 32-ounce gas liquor; B is to receive the solid sesquicarbonate; C contains some of the same gas liquor; D, the revivified liquor by this process; and E, some water. On heating A, most of the carbonic acid, sulphureted hydrogen, and ammonia are evolved, leaving the liquor caustic; while solid sesquicarbonate of ammonia collects in B. The excess of carbonic acid and sulphureted hydrogen passes through C, where carbonic acid is absorbed and crystals of bicarbonate of ammonia are deposited. The sulphureted hydrogen and the remainder of the carbonic acid pass into D, where they are completely absorbed, as no bubbles appear in E.

On analyzing the liquor I obtained 6,182·78 grains of carbonic acid per gallon, which is equal to 12,641·8 cubic inches; and only 250 grains of sulphureted hydrogen, which equals 652 cubic inches. You see what a very large quantity of carbonic acid it contains, and what a very small quantity (in proportion) of sulphureted hydrogen; and yet this strong liquor is still capable of absorbing (according to experiment) 2,350 more cubic inches of carbonic acid per gallon before it begins to crystallize out as bicarbonate. The



small amount of sulphureted hydrogen present is due to the superior affinity of the carbonic acid for ammonia; so that the sulphureted hydrogen is passed onward into the gas or into the liquor, where there is a small amount of carbonic acid. From this liquor I obtained twenty-eight ounces of sesquicarbonate, and ten ounces of the bicarbonate of ammonia crystals per gallon.

I shall now let the experiment take its course, and will proceed with a preliminary explanation, giving a general and scientific view of what goes on with the impurities in the distillation of coal—due to affinities or attractions brought about by a change in the strength of several solutions along with heat; all of which tend to bring about a rearrangement of the constituents. After this I will give details of the process that I have adopted in eliminating the impurities from gas, and in producing commercial salts without chemicals.

In the required natural process of the distillation of coal, the production of chemical salts from the waste gases, during the process of distillation, can be carried on continuously with perfect ease and harmony; or, perhaps, these concentrated solutions might more advantageously in some cases be sold to manufacturers. There are a number of salts which can be manufactured in this way—in fact, most of the salts which have for their components cyanogen, sulphureted hydrogen, sulphurous acid, carbonic acid, and ammonia. Providing we allow nature to take her own course of purification in isolating the permanent gases, which gases we require for illuminating purposes, by so doing we have concentrated solutions formed at various stages in the course of purification. When we take into account that, by the nature of its impurities, thay are capable of combining with each other, forming permanent salts, which are dissolved in the water used for washing the gas, it should be an easy matter to completely purify gas by its own impurities—all that is left for us to do is to inquire into and assist nature in carrying out the object in view.

In nature's process of condensation and purification of coal gas there are three points where concentrated solutions of salts are continually being formed.

First.—In the hydraulic main we have a solution of ammonia sulphocyanide, the strength of which varies somewhat. I have found it to contain from six to ten ounces of this salt per gallon.

Secondly.—At the condensers we have three separate and distinct layers of substances. The topmost layer consists of a light tar charged with naphtha and naphthaline. The middle or second layer is a clear reddish-yellow solution saturated with carbonate of ammonia. The third or last layer is a heavy tar which contains the light and heavy oils, etc. Here you see it is possible to separate the light and heavy tars for the purpose of distillation. At this point a great loss of ammonia may take place by sending away to the distiller a concentrated solution of carbonate of ammonia intermixed with tar of the same specific gravity. Part of this ammonia is also lost by the tar distiller in the distillation of the tar.

Third, and last.—We come to the scrubbers or washers—preferably washers, they being more scientific, and, consequently, more effective. This is the most important point of gas purification. The gas on entering the washers is charged with sulphur impurities and carbonic acid. These impurities can be completely absorbed by a series of washers, dispensing with purifiers and scrubbers altogether. It is impossible to finish a gas quite free from impurities by means of a scrubber. By reasoning out the fundamental principles of the washer and scrubber, we arrive at the conclusion that it is not possible to have a more efficient piece of apparatus than a washer in every respect except one—that is, the pressure which it gives. This is due to the dips, which can be easily overcome by the exhauster. These dips, however, need not be more than a quarter of an inch, as the lightest liquid at the top is that with which we want the gas to come in contact. If the end of the dip is enlarged and perforated with quarter-inch holes, equal to the area of the pipe, we shall have the gas subdivided into a large number of small bubbles. Take, for instance, a nine-inch dip-pipe; the enlarged end would require to have 1,316 of the quarter-inch holes. In this way we increase to a considerable degree the area in contact, due to the superficial area of these small bubbles. Let alone the sides of the washer and the surface of the liquid, with the pressure caused by the dip—it all tends to increase the absorbing power of the liquid; since if we wish to saturate a liquid with a gas we must have the liquid in a quiescent state with the gas bubbling through. On the contrary, if we wish to liberate a gas from a liquid, we shake it about and subdivide it as much as possible (as in the scrubber); we thus have the desired effect of obtaining the evolution of its gases.

Now I will say a few words about purifiers. In nature's process of purification they are not required, if we wish to work scientifically. To talk of using a solid for the purification of a gas is a grave mistake, as a gas only penetrates a solid imperfectly; it needs time, which here is an important factor. Taking lime, for instance, the carbonic acid is absorbed at once, chemically forming a solid body (carbonate of lime), which solid envelope or shell prevents the gas from following, except very imperfectly, its desired course through the solid material. Hence the great waste of time, labor, etc.—let alone waste of sulphur and carbonic acid, which should be sold in the liquor—involved. This all means cheaper gas, if we can dispense with these expensive purifiers.

Now I will pass on to my intermediate treatment of the concentrated solutions that nature is ever trying to make, by first eliminating the carbonic acid, which is the strongest of the three acid impurities. The consequence is that it passes the others onward to their proper place. In the intermediate manufacture I obtain two salt —the sesquicarbonate and bicarbonate of ammonia—of which I have specimens here, prepared from condenser liquor (of 12° Twaddel) from the Arbroath works. This liquor gave seventeen ounces of sesquicarbonate of ammonia—a hard solid salt, nearly as hard as marble. In this state it can be easily transported for manure, or for manufacturing purposes. As a manure it stands first, for the whole of its constituents are required in plant-life; also it possesses the power of rendering all the silicates, phosphates, and sulphates in the soil soluble, in which state they must be before they can be absorbed by the roots of plants. I further obtained six ounces per gallon of transparent crystalline salt, bicarbonate of ammonia. After the abstraction of these salts a highly caustic liquor remains, which is used for the abstraction of carbonic acid from the impure gas.

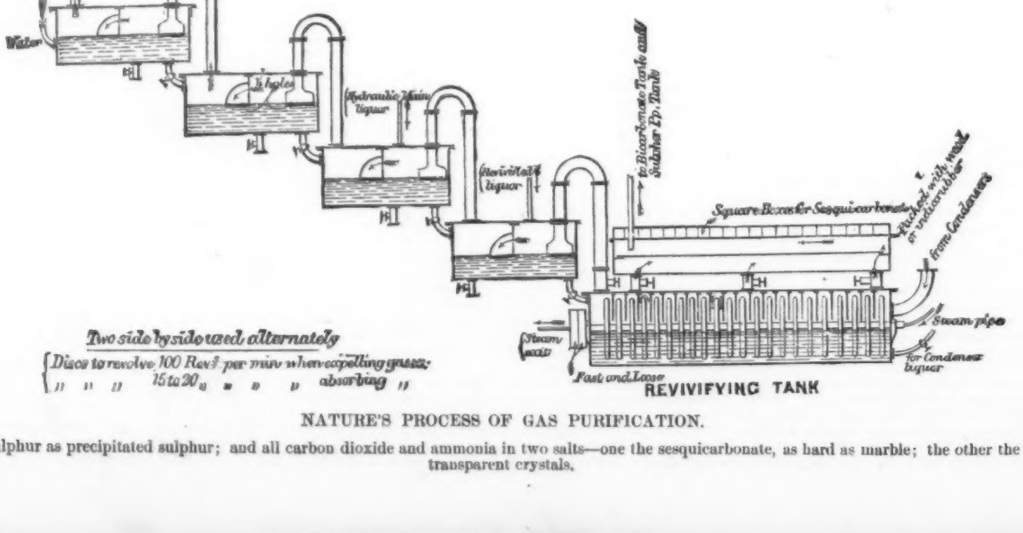
By this intermediate treatment of the liquor I have originated a new method of purification. That it is so is plainly visible when we examine the successive stages of purification, commencing at the hydraulic main, and passing onward to the washers. At the hydraulic main we have the impurities cyanogen, bisulphide of carbon, and sulphureted hydrogen, combined with ammonia, forming sulphide of ammonium and sulphocyanide of ammonium with free carbonic acid and ammonia. As the gases cool on passing to the condensers, a rearrangement of the impurities takes place; the sulphocyanide of ammonium is separated into bisulphide of carbon, cyanogen, and ammonia; the carbonic acid, taking the ammonia and expelling the others, leaves carbonate of ammonia in solution. There also the sulphide of ammonium undergoes a change, the carbonic acid appropriates the ammonia, forming carbonate of ammonia, and expelling the sulphureted hydrogen forward to the washers. This simple process of rearrangement is going on continuously in the condensers and first washer, until we get a liquor so charged with carbonate of ammonia that on being heated to the boiling point of water it gives up more than five cubic feet of carbonic acid, and at the same time from seventeen to twenty ounces of this salt—the sesquicarbonate of ammonia.

The way I propose to carry the process into operation at any gas-works would be to cut off the present connections at the end of the condensers next the scrubber, and dispense with scrubbers and purifiers. At this end of the condensers I should introduce a two-way pipe, connected to two rectangular boxes placed side by side, through which the whole make of gas could be passed alternately. After the liquor was rendered alkaline by the expulsion of its carbonic acid, ammonia, and sulphureted hydrogen—as will be explained—the gas on leaving these rectangular or revivifying tanks would pass on through the four gravitating washers, and thence to the exhauster, etc.

Now I will explain the action of the revivifying tanks. Each tank is to have a hollow cast-iron shaft passing through its center. On one end of this shaft (outside the tank) are two belt pulleys, fast and loose, for imparting motion. On the hollow shaft are fixed a number of hollow disks, at such a distance that the area between them shall be equal to the area of the inlet pipe. There is also a plate fixed between each disk, which is suspended from the top of the tank, and causes the gas to pass up one side of the disk and down the other, throughout the series. The hollow shaft and disks are so arranged that on steam entering the one end of the shaft it circulates through the whole series of hollow disks, and out at the other end. In this way a constant and uniform temperature can be kept up when expelling the salt. The vapor of this salt passes through the openings in the top of the tank, and finally settles into square recesses, about four inches deep and eight inches square, from which the salt is easily extracted in cakes, which are nearly as hard as marble. In this state it is ready for the market. When all the carbonic acid is driven out of the liquor, there remains a strong solution of ammonia; but by the time this solution has cooled down the adjoining vessel will have become saturated with carbonic acid. The gas may then be turned on through the solution of ammonia, which will greedily take out every trace of carbonic acid. Now steam can be turned on through the other vessel charged with carbonic acid, and so the process can be carried on repeatedly in this way. A close approximation as to the real quantity of carbonic acid, sulphureted hydrogen, and ammonia can be got at by the weight of salt expelled

The gas on leaving the revivifying tank contains a small quantity of carbonic acid, and nearly all its sulphureted hydrogen. These and other impurities are completely absorbed in passing through the four gravitating washers, which contain consecutively liquor from the hydraulic main, revivified liquor, and the last two washers clean water.

All the sulphur compounds will be found in the two



NATURE'S PROCESS OF GAS PURIFICATION.

Eliminating all sulphur as precipitated sulphur; and all carbon dioxide and ammonia in two salts—one the sesquicarbonate, as hard as marble; the other the bicarbonate, in transparent crystals.

washers nearest the revivifying tank. This liquor can either be sold to the manufacturer, or be rendered caustic in the revivifying tank; and all its sulphur extracted, by passing the evolved gas through an acid solution, when its sulphur is precipitated. In revivifying the sulphur liquor, either by itself or with the carbonic acid liquor, it would be of great assistance to bring a pipe from the chimney flue, so that its gases could be passed through the tank until all its sulphur compounds were expelled. This would greatly quicken the revivification of the sulphur liquor.

Thus by this process all the sulphur in the gas can be sold as precipitated sulphur, and all its carbonic acid and ammonia as carbonate of ammonia; both substances being in a dry and hard state, which is readily salable for manufacturing purposes, or for manure, etc.

When the liquor is being revivified by the passing of steam, the shaft and disks should revolve at about one hundred revolutions per minute; but when the crude gas is passing to be purified the shaft and disks should only revolve from ten to fifteen revolutions per minute. In this way the wetted surface is greatly increased during the expulsion and absorption of the gaseous impurities.

Here all the impurities of the gas can be sold instead of being passed to waste in the lime. Let alone the cost of lime and labor incurred therein, the saving here must be great, as the labor connected with the liquor process is very small—or, we may say, *nil*—when we take into consideration the extra profit to be obtained by the sale of sulphur and carbonate of ammonia.

We may say, then, that in time the scale of gas manufacture will be reversed; coal will be distilled for the value of its present by-products, and gas will be the by-product. The intermediate manufacture of salts is a step in this direction. The constituents of the salts can be easily doubled or trebled at will by many ways. Experiments are wanting in the way of research. Take for instance the cause for the formation of ammonia in the distillation of coal. What quantity (if any) is formed from the nitrogen of the air? If any, the quantity could be increased to any extent by taking into account the temperature and nascent state of nitrogen and hydrogen in the presence of red-hot carbon. Gas works will then be more appropriately called chemical works.

One word about gypsum. This substance, where it can be obtained at a low price, can be used with advantage instead of vitriol for making sulphate of ammonia, either by the manufacturer or in gas works. In the purification of gas, at a point where carbonic acid and ammonia are in a concentrated state, gypsum fixes both these impurities, forming sulphate of ammonia and carbonate of lime: thus

$CaSO_4$	+	NH_4CO_3	=	NH_4SO_4	+	$CaCO_3$
Gypsum		Carbonate of Ammonia	forms	Sulphate of Ammonia		Carbonate of Lime

Gypsum and common salt can be used in forming commercial salts; but I am sorry that I have not had time to complete my experiments in this direction. I am aware that both these substances have been used before in the process of distillation, condensation, and purification; but not in a successful manner. This is due to inexperience as to the real action and rearrangement of the impurities at various points in the process of distillation, condensation, and purification of coal gas. Common salt can also be used with advantage at a certain point in the purification of coal gas, completely fixing the carbonic acid and ammonia, forming bicarbonate of soda—which we get for the price of common salt—and leaving chloride of ammonium in solution. The chemical change on adding salt to the liquor is thus explained:

NH_3	+	CO_2	+	$NaCl$	+	H_2O	=	$NaHCO_3$	+	NH_4Cl
Ammonia		Carbonic Acid		Salt		Water		Bicarbonate of Soda		Chloride of Ammonium

The same action takes place on passing crude gas through a solution of salt in the washers, by fixing the volatile ammonia and carbonic acid. I may say that very pure carbonate of soda can be made in this way, either in the gas-works, or by the manufacturer in operating upon the liquor.

DISCUSSION.

The President said there was, no doubt, great room for improvement in the purification of coal gas; and if Mr. Valentine could purify gas by means of its own impurities (in closed vessels), as he had indicated, it was certainly a step in the right direction. Mr. Valentine spoke of many objections to the present system of purification; but he omitted to notice one, viz.: the unwholesome and nasty smell in connection with the cleaning out of purifiers. It was this that caused annoyance in a district in which gas works were situated. He (the President) trusted that the day was not far distant when gas would be economically purified in closed vessels.

Mr. W. Young said he had listened with a considerable amount of pleasure to the remarks which had been made by Mr. Valentine. Like a great many other scientific chemists, Mr. Valentine took it for granted that all his hearers were equally well versed in the subject as himself; and that they were able to follow him with all the clearness which came from knowledge. He (Mr. Young) regretted exceedingly that there had not been exhibited the necessary diagrams to illustrate the practical application of the chemical principle involved; but he quite understood these principles from a chemical point of view. There were many difficulties, however, which he thought would obstruct its practical application; at least, on the first blush, it appeared so to him. At the same time, he believed, from what had been shown even in so crude and elementary a way, that the process might be made available—more particularly in works in foreign countries, where there was difficulty in obtaining a supply of sulphuric acid to manufacture sulphate of ammonia—because by it the ammonia could be recovered from the gas as a commercial salt, and could be sent home to this country in a dry state. There was great difficulty in getting sulphuric acid transported to many foreign works. Mr. Bell, formerly at Gibraltar, had said that sulphuric acid would there cost £20 a ton; and this made his manufacture of sulphate of ammonia practically prohibitory. By such a process as had been described—which he (Mr. Young) might say was somewhat similar to one which had been tried by an English gas manager, whose name had just escaped his memory—this difficulty could be overcome. The ammoniacal liquid remaining after the removal of these salts was in a caustic state, and this caustic ammonia could be made to absorb a further quantity of carbonic acid, and it thus made a valuable purifying agent. However, it was difficult in a foreign country to get thirty-two-ounce liquor. It might be possible at home to get it at different times and under different conditions, and with a coal that yielded a large quantity of ammonia; but it was a very unusual strength of liquor. If they could be supplied with such liquor he did not think there would be any difficulty in conducting the purification of coal gas in closed vessels, as with such a strong liquor it could be cheaply rendered recaustic. Recently he had been paying some considerable attention to the elimination of sulphureted hydrogen and carbonic acid—more particularly the latter—from coal gas by means of ammoniacal liquor in closed vessels; and he had studied most carefully the basis upon which the process was built. It was well known that ammonia and sulphureted hydrogen, when brought together at ordinary temperatures, combined at once; but if the temperature was raised a little above 140° Fahr. they dissociated. However, water at this temperature had still a strong affinity for ammonia and held on by it, allowing the sulphureted hydrogen to pass away. In the same way carbonic acid was thrown out; but requiring a slightly higher temperature. Mr. Valentine proposed to take advantage of this slightly stronger affinity, to eliminate both carbonic acid and ammonia, and thereby obtain the carbonate of ammonia; leaving a portion of the ammonia in the liquor, in the caustic state, to be employed in purifying the gas. If instead of thirty-two-ounce he had only ten to twelve ounce liquor, which was the usual strength, he would find that the balance of the affinities in the ammonia, sulphureted hydrogen, and water, was not of such a nature as would enable him to conduct his process. He believed, instead of applying a liquid solution to the purification of coal gas, that if caustic ammonia were used—that was, added to the gas as it left the condenser—the problem might be solved. At present gas contained something like one per cent. by volume of ammonia. Such gas with the most refined scrubbing arrangement was only able to produce liquor equal to about twenty-two or twenty-three ounce strength. If another one per cent. of caustic ammonia were added, then they would be able to make much stronger liquor, and by treating this stronger liquor, they would have far less fuel to employ in the regenerative process. To illustrate his meaning, he referred to Mr. Hislop's process of revivifying lime. That gentleman, he said, commenced with lime containing ninety per cent. of hydrate. If instead of such lime, he had been presented with lime containing only twenty-five per cent., and he had to go on reburning it, it was evident that it would be impossible to recalcine with profit, because, he would have not only the lime to recalcine, but all the foreign matter as well. In the same way with ammoniacal liquor. If there was a weak solution, it would be necessary to treat the whole solution for three, four, five, or six per cent. of ammonia; whereas if there was a strong solution, such as could be prepared by putting caustic ammonia into the gas, and such as between the water, ammonia, and sulphureted hydrogen, the balance of affinities would enable them to work. The difficulty would thus be overcome. Then with regard to the application of chloride of sodium and gypsum, or sulphate of lime, to the manufacture of the salts of ammonia. This was by no means new. It had been tried before; but it, of necessity, entailed the application of apparatus which had led to its abandonment. Then with regard to the scrubbing vessel mentioned, he believed with Mr. Valentine that the best form of vessel was a washer, but with movable caps so as to leave the great mass of the water in a quiescent state. Mr. Valentine had taken notice of the fact which had hitherto, so far as he (Mr. Young) was aware, escaped the observation of almost every one, viz., the state the liquid should be in when it was absorbing gaseous compounds. If a bottle of soda water were shaken, gas was immediately liberated; whereas if water were taken in a quiet state it would absorb an immense quantity of carbonic acid, showing that the shaking of the water—whether by inducing a certain amount of heat, or by some physical action, which he could not explain—caused the gas to escape. But he had had his attention directed to this phenomenon—that, in order to get a liquid to absorb a large quantity of gaseous matter, it was absolutely essential that it should be, as far as possible, in a quiescent state, and prevented from spreading over a wide surface. Because, in so spreading, it had a tendency to give out its gas instead of taking it up; just in the same way as shaking water would liberate previously absorbed gas.

Mr. Valentine replied. He stated that he had not gone into the matter of the carbonate of ammonia, although he knew it had been done before, but not successfully. There was no reason, however, why it should not be done. It was easy, in the manufacture of the bicarbonate of ammonia, to get it from ten-ounce liquor.

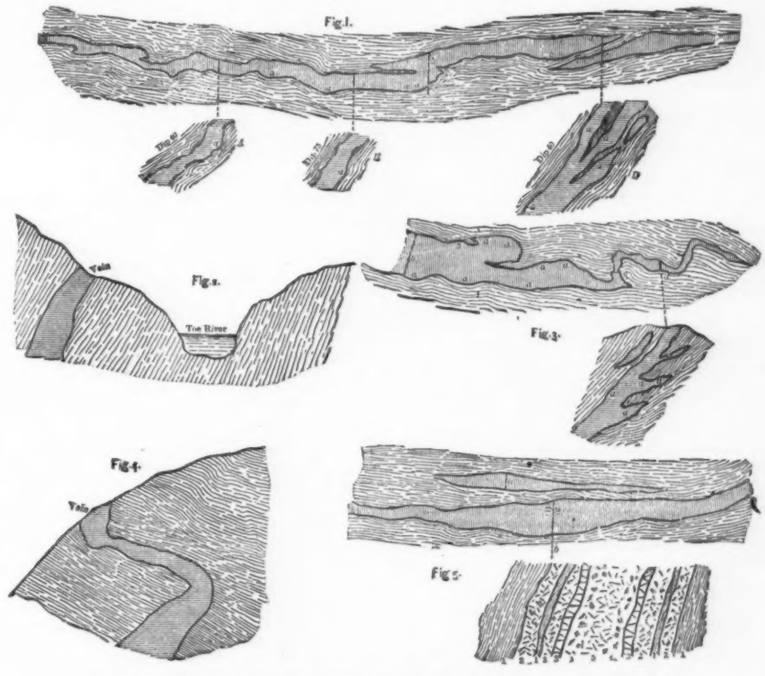
A vote of thanks was then acorded to Mr. Valentine for his paper.—*Journal of Gas Lighting.*

THE MICA VEINS OF NORTH CAROLINA.*

By W. C. KERR, State Geologist, Raleigh, N. C.

A BRIEF sketch only is here intended, with a few illustrations, in order to give a general notion of the character and structure of these veins. I have stated elsewhere, several years ago, that these veins were wrought on a large scale and for many ages by some ancient people, most probably the so-called Mound Builders, although they built no mounds here, and have left no signs of any permanent habitation. They opened and worked a great many veins down to or near water-level; that is, as far as the action of atmospheric chemistry had softened the rock so that it was workable without metal tools, of the use of which no signs are apparent. Many of the largest and most profitable of the mines of the present day are simply the ancient Mound Builders' mines reopened and pushed into the hard undecomposed granite by powder and steel. Blocks of mica have often been found half embedded in the face of the vein, with the tool marks about it, showing the exact limit of the efficiency of those prehistoric mechanical appliances.

As to the geological relations of these veins, they are found in the gneisses and schists of the Archæan horizons, in that subdivision which I have provisionally classed as Upper Laurentian, the Montalban of Dr. Hunt. These rocks are of very extensive occurrence in North Carolina, constituting in fact the great body of the rocks throughout the whole length of the State—some 400 miles east and west—being partially covered up, and interrupted here and there by belts of later formation. Mica veins are found here, in fact may be said to characterize this horizon everywhere,



SECTIONS OF MICA VEINS OF NORTH CAROLINA.

from its eastern outcrop, near the seaboard, to and quite under the flanks of the Smoky Mountains. It is, however, in the great plateau of the West, between the Blue Ridge and the Smoky, that the mica veins reach their greatest development, and have given rise to a very new and profitable industry—new and at the same time very old.

It may be stated as a very general, almost universal, fact, that the mica vein is a bedded vein. Its position (as to strike and dip) is dependent on and controlled by and quite conformable to that of the rocks in which it occurs, and hence, as well as on account of their great size, some observers, accustomed to the study of veins and dikes and the characters of intrusive rocks in other regions, have been disposed to question the vein character of these masses at first. But a good exposure of a single one of them is generally sufficient to remove all doubt on this score. The mica vein is simply and always a dike of *very coarse granite*. It is of any size and shape, from a few inches—generally a few feet—to many rods (in some cases several hundred feet in thickness, and in length from a few rods to many hundred yards, extending in some cases to half a mile or more). The strike, like that of inclosing rocks, is generally northeast, at a pretty high angle; but they are subject, in these respects, to many and great local variations, all the conditions being occasionally changed or even reversed.

An idea may be formed of the coarseness of these veins from this statement, that the veins of cleavable feldspar and of quartz (limpid, pale yellow, brown, or more generally slightly smoky) and of mica, are often found to measure several yards in two or three of these dimensions, and weighing several tons. I have a feldspar from one of these mines of nearly a thousand pounds weight, and I have known a single block of mica to make two full horse wagon loads, and sheets of mica are sometimes obtained that measure three or four feet in diameter.

There are many peculiarities about these veins. Among the most important, in a practical sense, is the arrangement of the different constituents of the vein *inter se*. Sometimes

* A paper read before the American Institute of Mining Engineers.

the mica, for example, will be found hugging the hanging wall; sometimes it is found against both walls; again it may be distributed pretty equally through the whole mass of the vein; sometimes, again, it will be found collected in the middle of the vein. In other cases where the vein varies in thickness along its course, the mica will be found in bunches in the ampulations or bellies of the vein. In still other cases where the vein has many vertical embranchments, the mica will be found accumulated in nests along the upper faces of these processess or offshots. These features of structure will be best understood from a few representative diagrams.

Fig. 1 is a horizontal section, with several transverse vertical sections, of a typical vein in Yancey county, at Presnel mine. The length of the section, *i. e.*, of the portion of the vein that has been stripped, is 125 ft.; the thickness varies from 3 to 10 ft., except at a few points, as *b*, *c*, where it is nearly 20 ft.

The crystals of mica are found in this mine generally near the foot wall, in the recesses or pouches; at *c*, however, as seen in section D, it is found next the hanging wall.

The inclosing rock in this case is a hard, gray slaty to schistose gneiss. The relation of the vein to the topography is seen in Fig. 2.

Another characteristic vein is well exposed at the Point Pezzle mine, in the same county, which has been wrought very successfully for several years. (Fig. 3.)

The inclosing rock is the same as in the former case. The mica here is found mostly next the hanging wall, and also in the offshoots or branches of the vein, as shown in the vertical section at *d*. This vein illustrates the exceeding irregularities which are often found in these intrusive masses—irregularities in form, size, and position—and the force with which the inclosing rocks have been crowded and bent and split in the effort of the vein matter to insert itself. The vein is 40 ft. thick at *b*, and 1 to 2 ft. at *c*. Fig. 4 furnishes another illustration of the same points.

Another class of vein is represented by the accompanying cross-section of one of the largest and most productive veins, on which was opened the first mica mine in this region (Sink Hole), in the bottom and top, with heavy forest trees of the age of 300 to 400 years. (Fig. 5.)

The lower part of the diagram represents an enlarged cross-section of the vein at *b*. The wall rock, 1, 1, is a soft, decomposed mica schist. A horse, of this wall rock, is embedded in the body of the vein on both sides, 1, 1. At 3, 3, occur interpolations of smoky quartz, and next to this, on both sides, at 4, 4, most of the best mica is found, though occasional masses of marketable mineral are found throughout the vein, at 5, and 2, 2. In the side vein, however, *a*, the mica is found mainly in the middle.

The extent and value of the mica industry may be indicated by some statistics of this single mine. The vein has been worked out to water level for nearly half a mile, and it is estimated that the aggregate length of its tunnels is more than six miles, and the yield of marketable mica above 40,000 lb.

In preparing the blocks of mica, splitting and cutting to the forms and sizes demanded by the markets, there is a waste of nine-tenths to nineteen-twentieths, even in a good mine.

The feldspar, which constitutes the larger part of the mass of these veins, is often found converted into beds of the finest kaolin; and, curious enough, this was one of the first and most valuable exports to England in the early part of the seventeenth century, "packed" by the Indians out of the Unaka (Smoky) Mountains, and sold under the name "unakeh" (white). This kaolin, like the mica, will doubtless soon come again into demand after lying forgotten for generations.

These are only a few of the more prominent characteristics of these very interesting veins. I have not referred to their singular richness in rare minerals, as samarskite, uraninite, gummite, allanite, etc., nor to many curious and unexplained relations between the marketable character of the mica—size, color, purity, fissility, etc.—and the special matrix in which the blocks are embedded. I do not know a better region for the study of the structure and origin of veins in general.

ON THE NEW METAL ACTINIUM.

By Dr. T. L. PHIPSON, F.C.S., etc.

SINCE the publication of my two notes in the *Chemical News*, vol. xliii., p. 283, and vol. xliv., p. 73, I have made a great number of experiments with the view of isolating the new substance to which the white zinc pigment owes its remarkable property of darkening in the sunlight, returning to its white state in the dark, and not being affected in this manner under a sheet of glass.

These experiments have at last proved successful, and a very short note to that effect was communicated, about a fortnight ago, to the Académie des Sciences, and another to the British Association on Monday, September 5. I will now describe the process by which I have isolated the oxide and the sulphide of the new metal in a state of tolerable purity. Perhaps this process may be improved hereafter, but it is not very complicated, though it has required an enormous number of experiments to arrive at it.

First, one word as to the manner in which the pigment found in commerce is prepared. Ordinary zinc scrap is dissolved in sulphuric acid, and a considerable excess of zinc is left in the solution in order to keep out iron, lead, arsenic, and other metals. The liquid is drawn off and then precipitated by a solution of sulphide of barium; the precipitate is dried, calcined, raked while hot into cold water, dried again, ground, etc. It then consists of sulphide of zinc, oxide of zinc, and sulphate of baryta, with *minute* quantities of iron, lead, arsenic, manganese, etc.

The manner in which I have obtained the oxide and sulphide of actinium from this pigment is as follows, and the process will doubtless serve for the treatment of other substances in which the presence of the new metal may be detected:

About fifteen grammes of the finely pulverized pigment are left for twenty-four hours in dilute acetic acid (strongest acetic acid and water equal parts) and the mixture well stirred or shaken occasionally. This takes out most of the iron, manganese, magnesia, lime, and *oxide* of zinc. The residue, after being washed, is treated exactly in the same manner with dilute hydrochloric acid (acid 8 parts, water 92 parts), with the object of completing the action of the acetic acid. The residue, well washed, is then heated with strong hydrochloric acid, to which a little nitric acid is added from time to time. The solution of the chlorides thus obtained is filtered to separate free sulphur and the insoluble sulphate of baryta, any remaining sulphur in suspension after filtration being oxidized by a few crystals of chlorate of potash. To this solution of chlorides somewhat diluted a considerable excess of caustic soda is added and the solution heated. The zinc oxide goes into solution, and the white oxide of actinium remains; the latter is received upon a filter, washed, dissolved in hydrochloric acid, and the solution again treated with excess of caustic soda (these operations may be repeated two or three times, in order to eliminate the zinc oxide as completely as possible).

Finally, the oxide of actinium, still impure, is washed on a filter and dissolved in a considerable excess of hydrochloric acid. The solution is neutralized by ammonia, and then the latter is added in excess.

All but a little iron oxide remains dissolved (if not, dissolve again in HCl and add ammonia in excess, which, this time, will only precipitate the iron). The iron oxide is separated by the filter, and to the filtrate sulphide of ammonium is added, which throws down the sulphide of actinium as a bulky pale canary-yellow precipitate, the color of which is best seen when it is received on a filter.

Oxide of Actinium.—The hydrate as precipitated by soda or ammonia forms a bulky white precipitate more gelatinous than oxide of zinc; unlike the latter it is only very slightly soluble in caustic soda, even when the liquid is heated; it is not precipitated by ammonia from solutions containing ammoniacal salts. It is a permanent white, with a slight tinge of salmon color when seen in bulk, and it does not change color when exposed to the air, as oxide of manganese does, neither does it appear to be affected by the direct rays of the sun. It is readily soluble in acids. The anhydrous oxide is not volatile nor decomposed by heat. It has a pale fawn-colored tint.

Sulphide of Actinium.—The hydrate as precipitated from its neutral or alkaline solutions by sulphide of ammonium is a bulky pale canary-yellow precipitate, insoluble in excess of sulphide of ammonium, scarcely at all soluble in acetic acid, readily soluble in mineral acids even when they are diluted. When exposed to the direct rays of the sun it darkens and becomes quite black in about twenty minutes, except in those places where it is protected by a piece of ordinary window glass.

The quantity of actinium sulphide obtained from the white pigment amounts to no less than about four per cent. This yield is enormous. The presence of this new element in zinc will account, probably, for the discrepancies noticed in the *equivalent* of this metal as determined by various observers. The new element differs very essentially from manganese, zinc, and cadmium, but has, perhaps, some points of similarity with lanthanum. It exists evidently in considerable quantities in, at least, some kinds of commercial zinc. As soon as I shall have written the next number of my "Journal of Medicine," I intend to pursue these investigations.—*Chemical News.*

THE GRAND CANON OF THE COLORADO RIVER.*

By CAPT. C. E. DUTTON, U. S. A., U. S. Geological Survey.

THE Grand Cañon of the Colorado River is the longest, widest, and deepest of the almost continuous chain of cañon valleys through which the upper half of that river flows. Its length is 218 miles, its width from 5 to 11 miles, and its depth from 4,500 to 6,000 feet. For convenience of discussion it may be arbitrarily divided into four divisions: 1st. The Kaibab division; 2d. The Kanab; 3d. The Uinkaret; 4th. The Shearwits division. The upper or Kaibab division is the grandest, widest, and most diversified, and a little deeper than the others. The three others are simpler in form and much alike in their topographical features. Capt. Dutton first exhibited a view of the cañon in the Uinkaret division, showing its simplest and most typical form. It consists of an inner and an outer chasm, or a cañon within a cañon. The outer chasm is five to six miles wide, and is walled on either side with palisades 2,000 feet high, of singularly noble and graceful profiles, which confront each other across a comparatively smooth plain. Within this plain is sunken the inner gorge, descending 3,000 feet lower, and having a width a little greater than its depth. At the bottom of the inner gorge flows the Colorado River, a stream about as large as the Ohio between Pittsburg and Wheeling. The strata in which the chasm is cut are chiefly of carboniferous age. The summit of the outer cañon wall is very near the summit of that series. The chasm throughout the greater part of its extent cuts below the carboniferous and penetrates the Lower Silurian, and even the Archæan schists, revealing the fact that before the carboniferous was deposited the country had been extensively ravaged by an erosion which swept away heavy bodies of Silurian, and probably also of Devonian strata. The carboniferous now rests upon the beveled edges of the flexed older strata, and in many places rests upon the completely denuded Archæan.

The region adjoining the chasm and for 40 to 60 miles on either side is a nearly level platform presenting the summit beds of the carboniferous system patched over here and there with fading remnants of the Permian. The stratum is very nearly, but not quite horizontal. There is a slight dip to the northward rarely exceeding one degree, but as the general course of the river is along the strike, the edges of the strata disclosed in the cañon walls are to all appearances rigorously horizontal.

From 40 to 60 miles north of the river are found the principal masses of the later formations, including the Permian, Trias, Jurassic, Cretaceous, and Lower Eocene. These form a series of terraces rising successively like the steps of a gigantic stairway as we move northward. Each formation is terminated southwardly by a great cliff, and the strata are nearly horizontal, collectively they have been named the Southern Terraces of the High Plateaus. The latest formation which was deposited in this region was the Lower Eocene.

To the geologist it is obvious that the formations of the terraces now terminated by gigantic cliffs once extended further out toward the southward and formerly covered regions from which they have been denuded. Captain Dutton is confident that all these terrace formations once reached entirely across the Grand Cañon platform in full volume, and that their ancient shore line is found in Central Arizona. The thickness of the strata thus denuded was a little more than 10,000 feet on an average, and the area from which they have been swept away is more than 13,000 square miles. It is through the heart of this denuded region that the course of the Grand Cañon is laid. The denudation began probably at an epoch not far from Middle Eocene time, since at that epoch took place the final emergence of the region from a marine condition (through the brackish water and lacustrine stages) to the condition of *terra firma*.

* Read before the A. A. A. S. Cincinnati, 1881.

It is apparent that the cutting and development of the present Grand Cañon is only a closing episode of a long history of erosion, extending from Middle Eocene time down to the present. Before the river could begin its attack upon the summit beds of the carboniferous which now form the crests of its upper walls, it had to cut through more than 10,000 feet of superior strata. This would alone indicate that the beginning of the present cañon cannot date far back in Tertiary time, and Capt. Dutton thinks that the evidence points strongly to the conclusion that its excavation in the carboniferous began in Pliocene time. This evidence is cumulative and not direct, but is derived from a comparison of many groups of facts which are too numerous and complex to be summarized very briefly. One group of facts bearing upon the question of age is found in the comparative study of the lateral drainage channels and their gradual extinction by the progressive development of the arid climate of the region which took place in Pliocene time. Nearly all the ancient tributaries of the Grand Cañon appear to have dried up at the beginning of its excavation or very soon after, and the whole work shows the influences upon arid climate.

The Grand Cañon district has also been subject to a great amount of uplifting, amounting in the aggregate according to locality, to 16,000 to 19,000 feet. The present elevation of its surface above the sea is the difference between the amount of uplift and the thickness of strata removed, and is from 7,000 to 9,600 feet. This great elevation is considerably surpassed in some other portions of the West. Obviously, it has been an important factor or essential condition in the process of cañon cutting.

The peculiar forms of the drainage channels of the Plateau country, and of which the chasms of the Colorado are extreme developments, are ascribed to the operation of two groups of processes acting under abnormal conditions. It is customary to say that the rivers have cut their cañons. This is but a partial truth, for the rivers cut passages no wider than their water surfaces. The first group of processes is termed corrasion, the result of which is the continuous sinking of the bed of the stream by the grinding action of flowing water charged with sand. Many factors enter into this result, and their mutual relations are highly complex. But in a general way it may be said that a river with a rapid descent, carrying a notable quantity of sediment, but not enough to overload it or overtax its transporting power, will continuously corrade or grind down and deepen its channel. If it is overloaded, a portion of its sediment will be deposited and form a protective covering to the bed-rock. Under special conditions it will actually build up its bed. Most rivers, along their middle and lower courses have their general conditions so adjusted that there is little or no tendency either to build up or corrade. To this equilibrium of adjustment all rivers are tending, and most rivers have nearly or quite reached it. The Colorado is exceptional in this respect, and its tendency is to corrade. Its waters, though carrying great quantities of sediment, are still under-loaded, and could carry more if they could get it. This tendency to corrade may be ascribed to the fact that the country through which it flows has been gradually rising in altitude through Tertiary and probably also Quaternary time, and this elevation produces and maintains a rapid declivity in the stream-bed, which in turn imparts a high velocity, and consequently great transporting power to its waters.

The widening of the cuts made by corrasion is the work of the second group of processes, viz., weathering. This is also a very complex action, and cannot be briefly summarized. To this action is due the remarkable sculpture of the cañon and cliff walls and all those surprising resemblances to architectural forms which are so abundantly displayed in the Plateau country, and most especially in the Grand Cañon.

The concluding portion of Captain Dutton's lecture was devoted to a description of the scenery in the Kaibab division of the cañon, which is declared by all who have seen it to be the most sublime and impressive spectacle in the world.

THE BRITTLENESS OF EMERALDS.

A CASE was decided in England a short time since which has considerable importance for those who are fortunate enough to possess valuable emeralds. Dr. Lynn, the well-known conjurer, was summoned to make good the value of an emerald ring which had been intrusted to him at one of his entertainments by a visitor for the performance of a certain trick. Somehow or other the stone became broken, and the allegation of the plaintiff was that the damage had been done by Dr. Lynn himself, while smashing with a hammer the egg in which the ring was finally found. Now it says much for the cleverness with which the trick was performed that the plaintiff firmly believed his ring to have been somehow smuggled into the interior of an egg. Of course this was not really the case; the adroit prestidigitator had the trinket elsewhere all the time, and only made it appear as if coming out of the broken egg. However there was no doubt about the stone being broken, and the sole thing, therefore, was to ascertain how it came by the injury. Only at one stage during the whole trick was the ring subject to the slightest violence, and this was when Dr. Lynn received it from its owner into a receptacle that already contained several coins. If the ring was either thrown in or let drop so that the face of the emerald struck against an edge of one of the coins the blow might have been sufficient to cause a fracture, especially if the stone had a flaw previously. Almost all emeralds are more or less flawed; indeed, it is doubtful whether such a thing as a perfectly flawless emerald has ever been known. The chances are, therefore, that the gem in question was in this imperfect condition, and that the concussion consequent upon its fall on the coins completed the fracture. Such, at all events, was the judicial decision in the matter, and Dr. Lynn carried the day. But, warned by experience, he now always makes an exception in the case of emeralds when he is asking the loan of a ring. Not all the magic of a conjurer's art can piece together a fractured precious stone; that feat beats Dr. Lynn himself, marvelous as are some of his manipulations, and it is just possible that some county court judge might hereafter believe, as did the plaintiff in question, that this Piccadilly Wizard has the power of wafting trinkets into the interior of unbroken eggs. Emeralds will probably play no further part in conjuring performances.—*London Globe.*

PHENOMENA OF OPTICS AND OF VISION.—The flame of a lamp appears brighter, and a vertical shaft, a post, or mast is seen more distinctly through a vertical than through a horizontal slit, while a house, a landscape, or the disk of the sun or moon is perceived more clearly through a horizontal slit.

THE ACROBATIC ALPHABET.

THE letterer and ornamenter may occasionally gratify his taste for drawing the human figure, by copying the contortions exhibited, which we find in the *Coach Painter*, taken from the *Fliegende Blätter*.

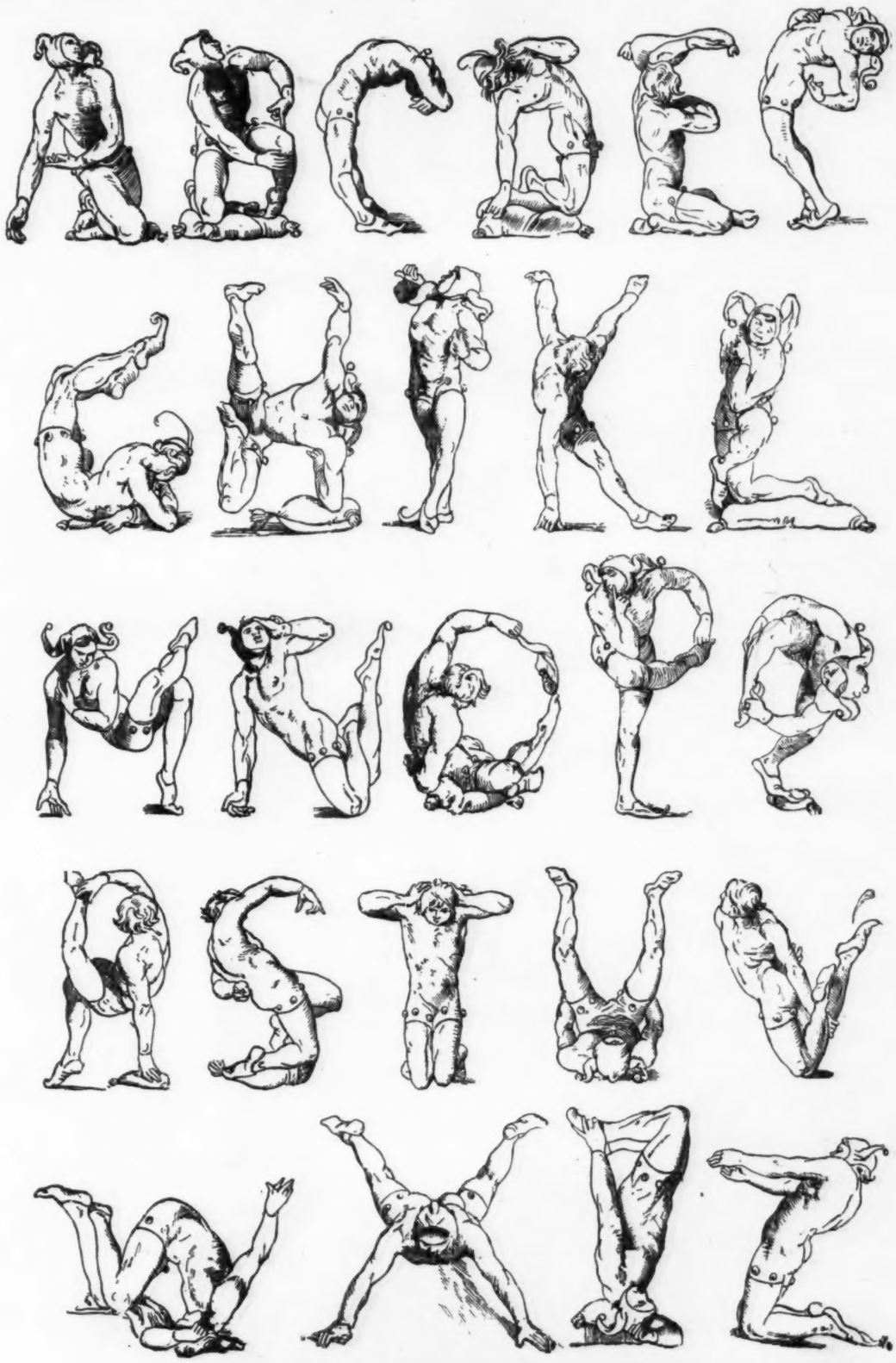
BANDS OF THE RAINBOW.

By C. RITTER.

IF the drops of water are at a less distance than 1·50 meters, we ought, when looking at them with both eyes, to perceive two distinct bows or rings; these bows will have their maximum interval on their horizontal diameter, and the interval, in the form of a crescent which separates the inner violet of the one from the outer red of the other, will decrease progressively to the upper and lower points of intersection of the two rings. At the distance of 1·50 meters the two bows are in contact, violet against red, on the horizontal line. Beyond 1·50 meters the bows cross each other on their whole circumference, but without ever producing complete superposition.

THE COST OF OUR CITY PUBLIC WORKS.

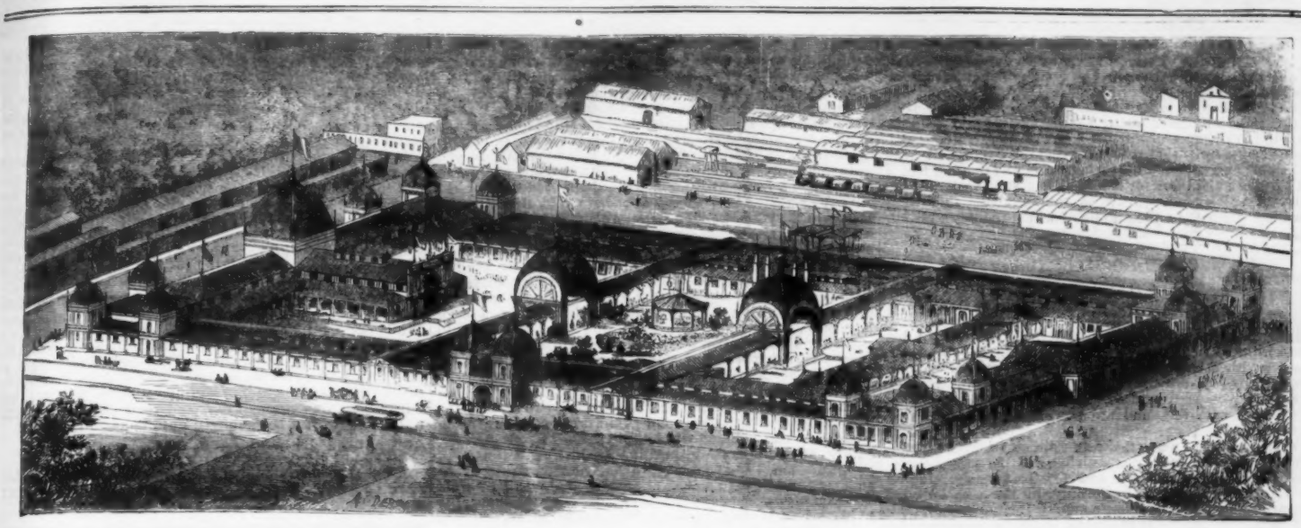
COMMISSIONER THOMPSON has sent to the Board of Estimate and Apportionment, an estimate of the amounts required to conduct the public business under the charge of the department of Public Works for 1882. The amounts asked for are, for aqueduct repairs, maintenance, and strengthening, $400,000; for boulevards, roads, and avenues, $100,000; for bridges across Fourth avenue, at Ninety-seventh street, $6,000; for flagging sidewalks and fencing vacant lots, $1,500; for contingencies, $4,000; for free baths, $33,000; for Fulton Market, alterations and rebuilding, $110,000; for Jefferson Market, alterations and rebuilding, $70,000; for lamps and gas, $570,000; for laying croton pipes, $250,000; for public buildings, construction, and repairs, $57,000; for surveys, maps, etc., $2,500; for public drinking hydrants, $8,000; for removing obstructions in streets and avenues, $10,000; for repairing and renewal of pipes, stop-cocks, etc., $200,000; for repairs and renewals of pavements and regrading, $200,000; for paving streets and avenues, $500,000; for roads, unpaved streets, and avenues, maintenance and sprinkling, $40,000; for salaries, department of Public Works, $89,000; for sewerage system, salaries, $15,000; for sewers, repairing and cleaning, $150,000; for street improvements, surveying and setting monuments, $1,500; for supplies for and cleaning public offices, $110,000; for supplying water to shipping and for building purposes, $10,563; for water supply for the Twenty-fourth Ward, $13,000; and for wells and pumps, repairing and cleaning, $500. The total amount asked for is $2,901,563.



SUGGESTIONS IN DECORATIVE ART.—THE ACROBATIC ALPHABET.

PUBLIC WORKS IN ITALY.—From details published in one of the Italian papers, it appears that no fewer than 686 public works, involving a total outlay of 98,500,000f., have been sanctioned by the Italian Government during the eight months ending the 31st ult. Moreover, within the same period, the surveys and specifications for one hundred and eleven new railway lines, covering a distance of 1,200 kilometers, and estimated to cost 205,000,000f., have been completed, and contracts have already been concluded for the construction of 810 kilometers of these new lines.—*Ironmonger*.

LIONESS AND CUBS.—DRAWN BY S. CARTER.



INTERNATIONAL EXHIBITION BUILDINGS, BUENOS AYRES, ARGENTINE REPUBLIC

LIONESS AND CUBS.

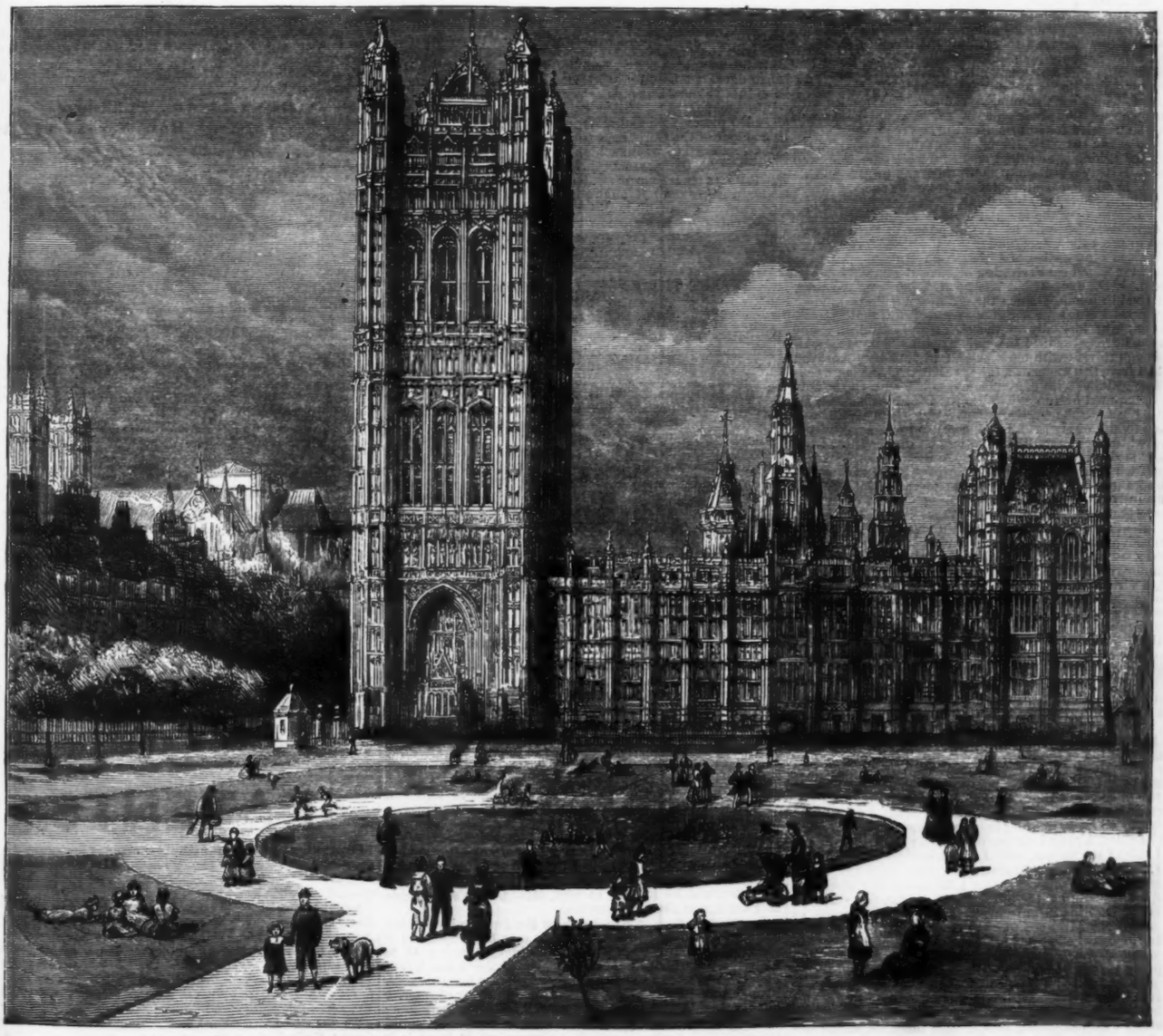
THE family group of a grand feline species, drawn by an artist, Mr. Samuel Carter, whose delineations of animal life are much commended for their truth and fidelity to nature, will speak for itself to each of our readers. There is a touch of that nature which "makes the whole world kin," and which brings even the brute creatures, at least the Mammalia, within the reach of human sympathies, in such an exhibition of maternal tenderness and infantine dependence, among the fiercest and most terrible wild beasts of the forest. It is a mother with her children, and that is saying much; the "harmless necessary cat," with her kittens in a basket, is not denied a certain respectful consideration in the household of gentle folk; the lioness with her cubs, so long as we do not fear to be torn to pieces for their meat, should be viewed with equal regard.

There is only the natural difference of size and strength, and the effect of domestication for many thousand past generations, to render our familiar companion in the kitchen and parlor less obnoxious than this formidable denizen of the Indian or African jungle. She is simply a big cat and a wild one, and the cubs or whelps are like their parent, as they ought to be; and the carnivorous races have as good a right to live as any others. It is not for man to reproach them with their appointed method of obtaining suitable food, but only to take care lest his own flesh or that of those whom he ought to protect should be appropriated to the leonine family larder. There is no such danger, however, in the case of animals kept by the Zoological Society in secure confinement behind a row of stout iron bars, and we may safely admire the subject of this drawing at a short distance outside the cage.—*Illustrated London News.*

THE EXHIBITION AT BUENOS AYRES.

IT is perhaps known to our readers that next year there is to take place at Buenos Ayres a great exhibition, in which the whole of South America has been invited to take part. This exhibition is to open on the 15th of February, 1882, and according to all accounts, promises to be a splendid affair. We give in the present number a general birdseye view of the buildings in which it is to occur. These form a great, long quadrangle, bounded by Centro-America, Piedad, Ecuador, and Rivadavia streets, and which is divided in the

LIONESS AND CUBS.—DRAWN BY S. CARTER.



THE NEW VICTORIA PUBLIC GARDENS, WESTMINSTER, LONDON.

direction of its length into two halls. The principal entrance occupies the center of the side shown in the foreground in the engraving, while the main exit is in a line with it on the opposite side of the structure. Of the two wings, the one to the left will contain the display of machinery, and the one to the right will be devoted to the agricultural exhibit. Close to the entrance of the first is the theater, which is surrounded by a court that is to be devoted to games and other diversions, and between the second wing and the first hall a track has been laid out for equine displays. Finally, in the center of the structure, between the two halls, there is a charming garden, in the middle of which there is a restaurant.

CLAUDIUS GALENUS.

A.D. 130—200.

By GEORGE JACKSON FISHER, M.D.

GALEN was a prolific medical writer. A portion of his manuscripts, which were deposited in the Temple of Peace, together with others which were in his own house, were destroyed by fire; not a few have perished by the lapse of time, and yet the aggregate amount of his writings which have survived, and are now extant, is something enormous.

Curiosity has led me to make an estimate of the comparative bulk of Galen's writings with that of the sacred Scriptures, including both the Old and New Testaments. Making a careful allowance for uniformity in the size of type, measuring the length of lines, counting the number of lines on a page, calculating the space lost by incomplete lines in a paragraph Bible, and the same in the Greek edition of Galen (5 vols. folio, Venice, 1525), I find that the united lines of the Bible amount to three miles and two hundred and forty feet. The united lines of the works of Galen extend to sixteen and one-half miles. In both cases the text is taken exclusive of all headings, references, notes, or commentaries—they stand as sixteen thousand feet to eighty-seven thousand, Galen's extant works being nearly five and one-half times more voluminous than the entire Bible. What a mass to read! What a vast mass to have been copied and recopied, with the pens of patient and industrious scribes, for a period of nearly fourteen centuries! Who can duly appreciate the value of the printing press?

It is supposed that he wrote no less than five hundred distinct treatises. We now have existing and in print no less than eighty-three treatises written by Galen, the genuineness of which is now fully admitted. To these are to be added eighteen of rather doubtful origin; forty-five undoubtedly spurious; nineteen fragments, more or less extensive in size; and fifteen commentaries on the works of Hippocrates. To these printed works must be added forty or fifty treatises, or parts of treatises, which still exist in manuscript in the public libraries of Europe. Of the number of works which are lost, including about fifty on medical subjects, it is supposed that they amount to one hundred and sixty-eight. Galen wrote not only on medicine, but also on grammar, mathematics, logic, ethics, and other branches of philosophy. Galen was familiar with all the dialects of the Greek language, which enabled him to communicate freely with the people and the profession of every country through which he traveled for information. The greater part of his writings are in the Attic, though he sometimes employed the Latin, the Ethiopic, and the Persic, in which he was well versed. His style is elegant, but diffuse and prolix, and he abounds in allusions and quotations from the ancient Greek poets, philosophers, and historians.

As an example of the familiar style in which Galen relates his experience, records his cases, and sets forth his own claims to perception, tact, and skill, I will here introduce Dr. Watson's translation of a case from Kuhn's edition of Galen,* the "Medical Profession in Ancient Times," by John Watson, M.D., 8vo, N. Y., 1856, p. 153–156: "Soon after my arrival in Rome, Glauco the Philosopher took a great fancy to me, in consequence of my reputed skill in diagnosis. Meeting me accidentally in the street and shaking hands with me, he remarked: 'I have fallen upon you opportunely. I wish you to visit with me a patient in this neighborhood whom I have this moment left—the Sicilian physician whom you saw walking with me some days since, and who is now ill.' I inquired of him what ailed his friend; when with his habitual candor he replied, that Gorgias and Apelas had spoken to him of my skill in diagnosis and prognosis, which appeared to them more like the result of divine inspiration than of medical science; and that he wished to know for himself whether I really was thus skillful. He had hardly done speaking before we reached the door; so that I had no opportunity of replying to his request—as I have often said to you—that on some occasions the signs of disease are certain, at other times they are ambiguous, and require to be considered again and again. But, as we entered, I observed a servant carrying from the sick chamber a vessel containing a thin bloody sanies, like the recent washing of flesh, a sure evidence of diseased liver. Without appearing to notice this circumstance, I proceeded with Glauco to the patient's apartment, when placing my fingers on the wrist of the sick man, I examined his pulse in order to determine whether the attack was inflammatory, or simply a weakness of the affected viscus. As the patient was himself a physician, he remarked that he had recently been up, and that the effort at rising might have accelerated the pulse; but I had already discovered the evidences of inflammation; and seeing on a recess in the window a jar containing something like a preparation of hyssop in boney and water, I knew that he had mistaken his disease for pleurisy; in which, as in inflammation of the liver, there is usually pain under the false ribs. He had been led to this opinion, I at once perceived, by experiencing this pain, by his short and hurried breathing, and by a slight cough. Understanding the case, therefore, and turning to good account what fortune had thrown in my way, in order to give Glauco a high opinion of my ability, I placed my hands over the false ribs, on the right side of the patient, and at the same time declared this to be the seat of pain, which the sick man admitted to be correct. Glauco, supposing that I had made this discovery merely by examining the pulse, began to express surprise. But to increase his astonishment, I added: 'Inasmuch as you admit the existence of pain at this spot, I wish you further to say whether you are troubled with a slight cough, and whether your cough is not dry, without sputa, and occurring at long intervals?' While I was yet speaking, the sick man was seized with a cough such as I had described; whereat Glauco was exceedingly excited, and no longer able to contain himself, began to vociferate in praise of my abilities. 'Do not think,' said I, 'that these are all the discoveries my art enables me to make; there are others yet to be mentioned, which will elicit the testimony even of the patient.' Then turning to the latter, I resumed: 'Is not the pain in this part increased, and accompanied with a sense of weight in the right hypochondrium, whenever you take a full breath?' At hearing this the patient also was surprised, and was as loud in my praise as Glauco. Seeing fortune still smiling upon me, I was desirous of making some remark in reference to the shoulder, which appeared to be drawn downwards, as often occurs in severe inflammations as well as in induration of the liver; but I did not venture to speak on this point, fearing to diminish the admiration which I had already excited. Nevertheless I touched upon it cautiously, saying to the patient, 'You will not long feel the shoulder drawn downwards, if perchance you do not find it so already.' When he admitted this symptom also, seeing him greatly astonished, I said, 'I will add but one other word to show what you conceive to be the nature of your complaint.' Glauco declared he would not be surprised if I should do even this. But the patient, overcome with wonder at such a promise, observed me closely, waiting for what I should say. I told him he had taken his disease to be a pleurisy. This, with a further expression of surprise, he admitted to have been his opinion, as well as that of his attendant, who had been fomenting his side with oil for the relief of that disease. From this time forward Glauco entertained the highest opinion both of me and of our art; for, having never before come in contact with a physician of consummate ability, he had hitherto formed but an humble estimate of the profession. I have related to you these particulars," he adds, as if addressing a class of medical students, "in order that you may understand that there are symptoms peculiar to particular diseases, and others common to several diseases; and, further, that there are some symptoms inseparable from the disease, some usually accompanying it, others again of uncertain character or of rare occurrence; so that if fortune at any time offers to you a good opportunity, as in the instance just related, you may know how to take advantage of it; remembering that fortune often presents to us the means of acquiring fame, which, through ignorance, many are unable to turn to good account." Excusing the conceit of our author, it is extremely interesting to listen to his fluent sentences which have come down through the long lapse of ages, as fresh and familiar as if spoken but yesterday. The methods of acquiring fame which he has here taught continue in use, and prove very serviceable to not a few of the modern disciples of Galen.

It is not within the limited scope of these "sketches" to attempt an analysis of all the works of Galen. I will hence confine myself to a brief notice of the more practical treatises, and particularly those which relate to anatomy and surgery. The treatise "De Usu Partium," which is in seventeen books, and is preserved entire, written soon after his return to Rome, was not intended for a mere professional text-book; but was rather a dissertation on final causes, to disprove the doctrines of Epicurus, and to demonstrate the existence of a superintending Providence, as manifested in the marvelous adaptation of means to ends which the structure of the human body so admirably displays. It is full of anatomical detail and physiological opinions. It is here we find those hymns and pious ejaculations to the all-wise and omnipotent Deity—sentiments worthy not only of the heathen philosopher and moralist, but of the most devout worshiper of the Christian's God. While it would be obviously absurd to set up a high claim for the amount and accuracy of the anatomical knowledge possessed by the ancients in the time of Galen, as compared with that of modern times, yet it ought to be known that most of the descriptive terms both in physiology and pathology, as well as in anatomy, which are now in use, were employed by him in the same sense as they are employed by modern authors.*

—*Annals of Anatomy and Surgery.*

* Vol. 3, p. 361. "De Locis Affectis," lib. v., c. 3.

* Vide *Kidd*. A cursory analysis of the works of Galen, so far as they relate to anatomy and physiology. Trans. of the Provincial Med. and Surg. Asso., vol. vi., p. 299–336, to which I am much indebted.

AN INSECT THE CAUSE OF EPIDEMIC CHOLERA MORBUS.

IN a communication to the *Union Médica* of Venezuela, Dr. Beauperthny, of the Universities of Paris and Caracas, asserts the cause of epidemic cholera morbus to be the sting of an insect belonging to the order *Hemiptera*, class *Homoptera*. Puncturing the skin of animals, the insect deposits its virus in the subcutaneous tissue. The puncture resembles that of a mosquito, and does not give rise to much pain. When the point affected is rubbed immediately after the introduction of the poison, and before the latter has been absorbed, livid greenish spots are produced similar to those resulting from the bite of venomous serpents. One sting of the insect is not sufficient to cause fatal results; the gravity of the disease varies according to the number of punctures made and their location. The author then points out the analogy existing between the symptoms resulting from the bite of venomous serpents and the symptoms of cholera morbus. Investigations begun in 1838, made in various localities and continued up to date, lead Dr. Beauperthny to assert that fevers depend upon a vegeto-animal virus, whose introduction into the body in the majority of cases is a true inoculation.—*Medical Record.*

PRESERVING AND CANNING.

A CORRESPONDENT of the *Country Gentleman* says: The best vessels for preserving or canning purposes are either porcelain-lined iron kettles or yellow ware dishes. These should be rather large in circumference, and not too deep, to allow the fruit to be done equally, which will be found to be impossible if they are too much heaped. They should have covers to them, to fit closely, to be put on after the scum has done rising, so that the flavor of the fruit may be kept in with the steam.

The water used for melting the sugar should be pure and clear, not having the least sediment in it. Any impurity will injure the clearness of the sweetmeat. A perforated skimmer and a thin wooden spoon should be kept expresaly for this purpose. I would here mention that after buying wooden spoons, and before you use them at all, it will keep them from splitting if you grease them thoroughly with lard or butter, and let it soak in well, laying them somewhere near the fire to effect this purpose.

In preserving, it is best to allow the fruit to boil rather quickly, so that the watery particles may be evaporated at once, without being subjected to so long a process as to spoil the color and diminish the flavor of the fruit; but if they are not boiled sufficiently, they will not keep so well. Fruits canned or preserved may be done in sugar of inferior quality, but they will not look as well and will spoil more easily. If too small a quantity of sugar is used, they will certainly not keep. When this experiment is tried, it is generally found to be false economy. Jelly bags should be made of white flannel, and be wrung out of hot water, to prevent their absorbing too much of the juice. After the liquor is all in, the top of the bag should be tied close, so that none of the flavor may evaporate. It is a very good plan to have a wooden frame made to tie the jelly bag on while it is dripping.

It is better to put jellies, jams, and marmalades in small glasses, and to cover them with double tissue paper. If you find that any of them become candied, you can remedy this by setting the glasses in water, and letting it boil around them. In boiling most fruits it is better to boil them in water first, and add the sugar when the fruit has become soft and the juices drawn out. To make the sirup for preserves, take, to eight pounds of the best sugar, the whites of four eggs, beaten up to a stiff froth and stirred gradually into two quarts of very pure spring water. Put the sugar into a porcelain kettle, adding the water and white of eggs. While the sugar is melting, stir it frequently, and when it is entirely dissolved set it where it will boil carefully, taking off all scum that may arise. The small fruits, such as raspberries, strawberries, currants, gooseberries, etc., if perfectly ripe, may be put into sirup prepared in this way, and will retain their form, color, and their fresh and natural taste. They must be simmered until done quite through.

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